The
ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

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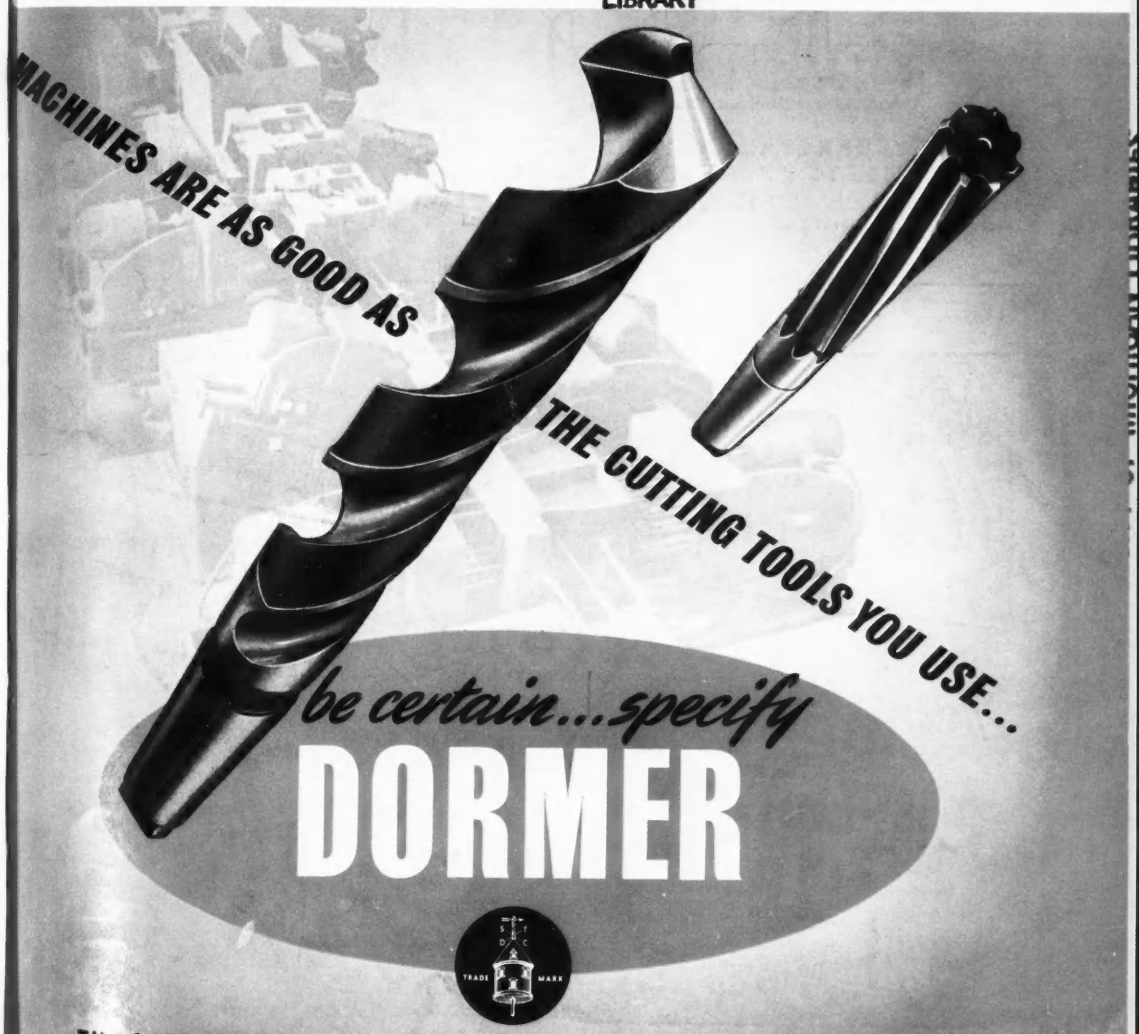
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THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *IMPROVED GOLD PLATING PROCESS*

It is reported that the introduction of a new process has now made the gold plating of many industrial and consumer products an entirely practicable proposition both as regards cost and quality. Gold plate has many merits as a coating. Its low electrical resistivity, and its high resistance to tarnish, oxidation, and attack by salt spray and corrosion make it adaptable to a variety of industrial applications. It also imparts a richness of styling which is an important competitive factor with many consumer products. In the latest type of electro-plating process, the costly intermediate scratch-brushing and buffing operations are eliminated. Moreover, it is claimed that the deposits have physical characteristics which make it ideal for both industrial and decorative purposes. Industrial gold plating applications generally require relatively heavy deposits—as much as 0·0001 to 0·005 in. Previously, the only method for plating thick deposits was by the use of a hot cyanide bath. Plated parts to be densely coated had to be intermittently scratch-brushed or buffed. This operation was costly and deposits were coarse-grained. Specified thicknesses were a hit-and-miss proposition. The new process eliminates these objectionable features and produces heavy deposits. Plating is effected with a high-cyanide, low-temperature electrolyte having a gold metal concentration of about one troy ounce of metal per U.S. gallon. The solution is mechanically agitated and operates at normal current densities. Cathode efficiency approaches 100 per cent. This allows accurate deposition of plate thickness to meet exact specifications. The bath is said to be simple in operation and easy to maintain. Although it is a precious metal plating process, production plating is done with conventional equipment. As the bath operates at room temperature, the process is well suited for protective plating of assembled units, soldered assemblies, or delicate precision parts.

● *CONTINUOUS CASTING OF IRON AND STEEL*

It has been shown in the metal industry that the best process for the production of sound billets or bars of non-ferrous metals is that of continuous casting. This accounts for the almost exclusive use of this process to-day in non-ferrous metal industries. The advances made in this field have encouraged experts to attempt to use the continuous casting method for the commercial production of billets and rods made of steel or iron. However, numerous experiments over a period of many years have up to now been more or less unsuccessful, because the product was of lower quality than that produced by the usual mould process. For example, bars of ingot steel with 0·15 to 0·20 per cent C, 0·40 per cent Mn, and 0·20 per cent Si, produced by the continuous casting method, have shown radially distributed gas bubbles and axial cavities, or pipes in perpendicular section, resulting in a practically useless material. When it was found that difficulties could not be avoided by varying the conditions in the process, further experiments in the continuous casting of steel were discouraged. It is now claimed that these difficulties are overcome in a recent invention, which makes it possible to produce satisfactory continuously cast billets or bars of steel or iron. The main feature of this invention is that the process is so arranged as to produce a non-deformable solidification shell in the continuous casting mould. At the same time, solidification of the molten interior of the casting is delayed and so adjusted that it does not take place until the gases have had time to escape.

● *PREVENTING DECARBONISATION DURING HEAT TREATMENT OF STEEL*

When steel is heat treated in fused salt baths it has often been found that the baths, especially in operations of long duration, exert on the treated articles a decarburising action which increases with time. To avoid the decarburising action of these baths, attempts have been made to add substances which either counteract the decarburising effect or else prevent it in one way or another. For this purpose, alkali metal or alkaline earth metal cyanides are, for example, used, especially at relatively low hardening temperatures of up to 950° C, while borax or acidic oxides, such as those of titanium or silicon, are used for baths operating at higher temperatures. It is possible to suppress decarburisation considerably at temperatures of up to 950° C by using cyanides as additions to the hardening baths. It is claimed that decarburisation can be surpressed with certainty even in the case of hardening baths operated at higher temperatures, as, for instance, barium chloride baths operated at 1000 to 1300° C, by adding to the salt bath a halide or oxyhalide of magnesium. This is

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said to entail no disadvantageous effects with regard to the formation of undesired slags. Particularly good results are reported with magnesium fluoride. Investigations have shown that decarburisation in barium chloride baths is apparently caused by the formation of iron oxide, which originates from the crucible or the electrodes and is further promoted by barium oxide, formed during melting from the barium chloride, by the action of moisture and water of crystallisation. The beneficial effect of magnesium fluoride in preventing decarburisation is attributed to the fact that apparently the barium oxide reacts with magnesium fluoride to form barium fluoride, and magnesium oxide, and is thus removed.

● *LIQUID-COOLED HOT GAS DUCT*

The high gas temperatures employed in gas turbine and jet propulsion technique make it necessary to conduct gaseous media at high temperature through pipes and passages. Similar conditions exist in steam power plant, where the simultaneous presence of high temperature and high pressure serves to aggravate the problem. A suggestion has been made to protect the walls of a pipe against the high temperature of the fluid medium passing through it by covering the internal wall surface with a water film, which is maintained unbroken by introducing additional water supplies at the points where it tends to disappear through evaporation. That the cooling effect of such water films is considerable is amply confirmed by the burning of high-power electric arcs of the Gerdien type in tubes, the walls of which are covered with a vortex of water introduced tangentially into the tube. A recent investigation was concerned with the use of liquid cooling films in tubes carrying hot air at temperatures of up to 2000° F. In order to study film formation, transparent tubes were used for these experiments. It was found that a cooling film could be satisfactorily maintained and that the tube wall temperature remained well below the boiling point of the water. With high rates of hot air flow, the liquid film was found to be disturbed by turbulence, so that increased loss of water from the film resulted. In order to ensure a satisfactory cooling effect over the entire length of the pipe or duct to be cooled, it will therefore be necessary to consider the maximum gas flow velocity that can be employed without creating excessive water requirements. Also, the location of points of water admission will have to be carefully chosen.

● *ULTRASONIC CLEANING PROCESS*

There already exists a number of industrial processes, in which ultrasonic vibrations are used to clean the surface of metals prior to additional treatment. An apparatus has now been announced in which ultrasonic vibrations can be applied to a wide range of industrial cleaning operations. In this equipment, use is made of a synthetic ceramic transducer element. This element, which was especially developed for industrial applications, resembles a pipe, six inches in length, cut in half along its longitudinal axis. The shape of the element has the effect of focusing along a line ultrasonic vibrations, generated by the element by means of the usual electrical method. This focusing effect results in a region of extreme turbulence, which produces a cleaning action of deep penetration. It is this action which serves to remove almost instantaneously all dirt, grease, chips, and microscopic particles of soil, etc., from the most intricately designed and close-fitting parts, when these are placed within the ultrasonic field of action. The electrical part is so arranged that a potential of only 40 V is required to operate the ceramic transducer, the frequency of the ultrasonic vibrations produced being 430,000 cps. Because of the low voltage used, the transducer can be safely immersed directly in the solvent used for cleaning. Trichloroethylene is used at present as a solvent, but other media can also be used. It is claimed that one such ultrasonic cleaning installation is now in successful operation at the plant of a prominent manufacturer of dry shavers, and that the cleaning unit permits precision cleaning of shaver heads at a rate never before equalled by other cleaning methods.

● *PLASTIC PIPE PROGRESS*

Plastic pipe made of polyvinyl chloride is finding extensive application in chemical industrial plant, as it is not subject to corrosion attack by nearly all corrosive chemicals, including highly concentrated acids. The two chief obstacles to a still wider use of polyvinyl chloride piping are, of course, the limited temperature and pressure ranges for which this product may be used. While basic considerations of a chemical nature will make it difficult to produce plastics suitable for high temperature ranges, such limitations do not exist in the production of plastic piping for high operating pressures, as this is largely a mechanical problem. Several products exist in which the pressure problem has been solved by producing plastic pipe with glass fibre reinforcement, and one maker claims to have produced a pipe capable of withstanding pressures of up to 600 psi. However, this system of reinforcing the pipe itself would appear to call for special methods of making branches and fittings of various types and of making the joints. A more promising solution consists in encasing standard plastic pipe, capable of withstanding some 85 to 100 psi, in a metallic sheathing designed to take the pressure stress. In developing this tubing, many difficulties were encountered owing to the considerable difference in the thermal expansion of the casing material and the pipe itself. It is reported that this problem has now been solved by resorting to a method of manu-

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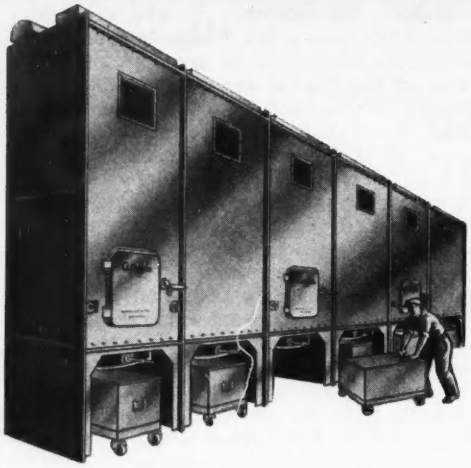

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facture in which the metal casing after application is subjected to a reeling process, resembling that employed in the production of seamless steel tubing. By applying this treatment to the pipe cover, the encased plastic material is placed under a permanent axial and tangential stress, which completely overcomes expansion difficulties.

● *STRESS CRAZING OF PLASTICS*

The initiation of crazing in transparent plastics is an undesirable feature, which greatly limits their use in engineering applications. Various factors such as temperature, time, orientation, environment, etc., have an influence on the initiation of crazing, but local stress intensity is probably more directly responsible for its occurrence and subsequent propagation than any other factor. Crazing in plastics has been defined as visible mechanical cracks or as submicroscopic failures, resulting in a noticeable "blushing" of an otherwise transparent material. In such applications as transparent enclosures on aircraft, transparent instrument panels, and insulators in electronic apparatus, the initiation of crazing is definitely a cause for alarm, either because of loss of transparency, loss of mechanical strength, or loss of dielectric properties as a result of moisture absorption in the crazing openings. Also, since crazing once started will continue to increase without an increase in load magnitude, it is well to avoid its consequences by taking every precaution to avoid its inception. It has been reported that crazing can be greatly retarded or even prevented from occurring by applying to the outside surfaces some synthetic-polymer coating. For polystyrene, one such coating is a solution consisting essentially of styrene monomer. It is obvious that working stress magnitude should be established not merely on the basis of static ultimate strength, but on strength values at which crazing is found to occur. Where the plastic part may be subjected to tensile stress in varying directions, full annealing of the transparent plastic sheet is highly desirable, as in this way the material can be made more nearly isotropic.

● *BRAIDED ELECTRODES FOR WELDING*

In the inert-gas arc welding process, the electrode, which is a long filler wire, is usually wound on a reel so that it can be fed continuously into the weld by the motor driven feed mechanism. Hitherto, the process has been limited to the use of wires made of materials which are ductile enough to permit winding of the wire. This requirement excluded many special materials with specific properties, such as corrosion resistance, hardness, or bearing properties, which either could not be made in small diameter wire or which were too brittle to be found on reels. It has now been proposed to circumvent this difficulty by using braided or stranded electrodes and making small electrode wires by compositing the ductile elements. This method makes it possible, for instance, to provide a braided wire type electrode for aluminium bronze, which cannot be produced in the form of alloy wire, owing to lack of ductility when the aluminium content exceeds 10 per cent. In this case, the electrode is made by stranding electrolytic copper, electrical conductor aluminium and low carbon steel wire. When the braided wire is melted in a welding arc, the elements are thoroughly mixed and alloy together. Thus, the chemical composition of the final alloy merely depends on the relative amounts of alloying constituents supplied in wire form. Welds made with stranded electrodes appear to have a strength comparable with that of welds made with solid metal electrodes of the same composition. The joint strength developed in steel is equivalent to that developed by some of the mild steel electrodes. The deposits also provide good bearing surfaces when employed to overlay steel parts subject to sliding friction.

● *HIGH-SPEED ELECTRIC MOTORS*

Extremely high speeds are often required for electric motors used in development and research work. A prominent firm of electrical manufacturers has recently designed and built a three-phase motor, the speed of which is infinitely variable between 6000 and 60,000 rpm, the output approximating 5 kW at maximum speed. The motor employed is of the squirrel-cage induction type. As its speed is changed by varying the frequency of the current supplied to it, and as it is built as a two-pole machine, it requires supply frequencies from 100 to 1,000 cps, in accordance with the speed range mentioned above. To provide current at frequencies within these limits, two cascade-connected frequency changers are employed. The first of these produces current at a frequency of between 100 and 300 cps; the second supplies current at frequencies ranging from 300 to 1,000 cps. Each of these two machines is driven by a d.c. motor, which in turn is fed by a Ward-Leonard controlled motor-generator. The converters are fed with 50-cycle a.c. for excitation, and are driven in a direction of rotation opposite to that of the field. By a variation in speed of the d.c. motor between 600 and 3,000 rpm, current at a frequency of between 100 and 300 cps is then supplied to the rotor of a 24-pole alternator, also rotating in a direction opposite to that of the field, and driven at variable speed with a maximum speed of 3,500 rpm. Current with a frequency of 1,000 cps is obtained at the stator of this machine when it is running at maximum speed. The capacity of each of the frequency changers if 7·5 kVA. The motor running at 60,000 rpm is provided with bearings of special design and a special oil circulation system for the journal bearings, which are of the hydrodynamic type.

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● *RARE EARTHS IN STAINLESS STEEL*

A recent paper compares the effects of misch-metal with the use of rare-earth oxides in the making of stainless steels. It has been known for some time that the use of cerium and lanthanum makes it possible to improve the properties of stainless steel, and data have been established which show the range of cerium and lanthanum needed to overcome hot-shortness in alloys containing chromium, molybdenum, tungsten, nickel, and copper. Improvements in grades of stainless steel which are not ordinarily workable have also been confirmed when mixtures of rare-earth oxides and suitable reducing agents are added. A number of products has been developed, these being mixtures of the rare earth oxides with borides, nitrates, and silicon, which are supposed to reduce the rare-earth oxides at the molten steel temperature. These mixtures are used as ladle additions to stainless steels for the purpose of improving the hot-workability of the material. Ladle additions of the order of one to four pounds per ton are used in the case of inherently ductile steels. Experience with these mixtures to-date is that no cerium or lanthanum content could be detected in the resulting steel. No significant amount of cerium or lanthanum appears to be recovered, and it must therefore be concluded that the mechanism of the effect obtained with the use of rare-earth mixtures is different from that of the misch-metal additions. Moreover, rare-earth oxide mixtures were not found to improve the hot-workability of austenitic steels, which are essentially hot-short or difficult to work hot, and which are improved by a residual cerium and lanthanum content of 0·2 to 0·25 per cent.

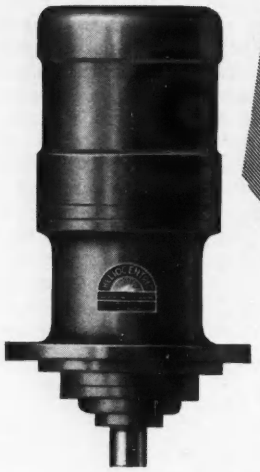
● *VACUUM AS A TOOL IN METALLURGY*

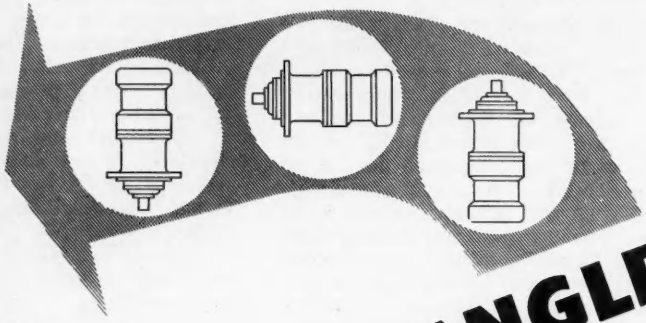
The increasing realisation of the adverse influence of gas content upon the properties of metals and alloys has produced a widening interest in the use of high vacuum as a metallurgical processing tool. In fact, the embrittlement of certain metals by gas content, the unsoundness of castings resulting from gas liberation, the deleterious effects of gases on magnetic and other physical properties, and other difficulties in fabrication due to gaseous compound inclusions have served to emphasise the potentional advantages offered by metals with low gas content. Thus, it has been found that the use of vacuum melted steel in the production of ball bearings results in endurance properties beyond the limits of experiments devised to measure bearing failure. The success of processing in vacuum rests, of course, upon the complete elimination of gases from the melt before pouring, without having to resort to the addition of elements leaving residuals which are also troublesome, but in a different way. In the case of high purity copper castings, for instance, for electrical and electronic applications, the use of solid deoxidants cannot be tolerated because of their effect in solution upon electrical conductivity. Vacuum deoxidation and casting permit the production of very sound parts of high conductivity. In addition to the decrease in gas content and the resultant increase in soundness, vacuum processing also removes other impurities which are volatile at low pressures. Vacuum processing also offers the possibility of improving methods of heat treatment, annealing, bright annealing, sintering, and ageing. Thus, exceptionally good results have been obtained in bright annealing of strip and sheet in vacuum. Surface condition and fatigue life of certain spring materials have been improved by ageing in vacuum.

● *METAL POWDER CEMENT WITH CONTROLLED EXPANSION RATE*

An outstanding advantage of powder metallurgy is that it enables unusual combinations of metals, or finished products, with special properties, to be made. A little known, but very important, application of this type is the use of special mixtures of powders having linear and volumetric expansion properties which cannot be secured easily or economically by any other method. A typical example is the cementing material used to mount industrial diamonds in a metal holder. Where a diamond is used to dress abrasive wheels, a very considerable amount of heat is generated. This heat generation is highly localised and may reach temperatures as high as 1000° F. Rapid heat dispersion is accomplished by making the holder of relatively great mass and by using a cementing material which is metallic and has a high thermal conductivity. A special powder mixture has been developed which, after sintering, constitutes an alloy having the required thermal conductivity and developing a strong bond both with the diamond and the metal of the tool holder. To mount the diamond, the tool shank is drilled to take both the diamond and a small amount of the alloy powder. The diamond itself is cemented into a small graphite holder and then pressed into the hole filled with the metal powder. By the simultaneous application of pressure and heat, the diamond is pressed into the alloy powder and the powder sintered. This operation forces the powder around the diamond, so that mechanical bonding occurs ; at the same time, there is an alloy bond formed between the cementing material and the metal holder. In this case, induction heating can be advantageously employed.

For further information on developments reviewed in THE BLUE PAGES, readers are invited to write to the Editor.





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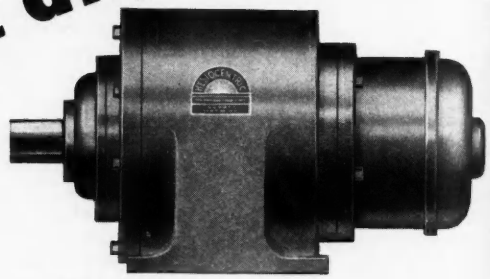

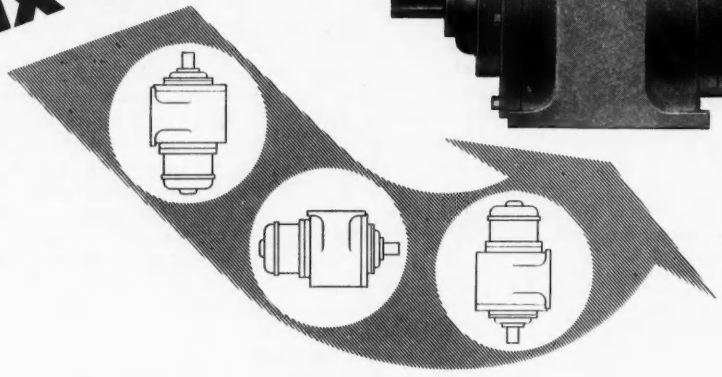

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REVIEW OF WORLD ENGINEERING PROGRESS

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Chemical Plant Economy through Standardisation

By D. R. KECK. (From *The Engineering Journal, Canada*, Vol. 36, No. 7, July, 1953, pp. 833-839, 9 illustrations.)

Briefly outlining the various manufacturing operations at the Canadian Chemical Company's new plant in Edmonton, Alberta, this paper describes the lengths to which standardisation has been applied to refinery type equipment in the petrochemical area, such as distillation towers, tanks, heat exchangers, pumps, instruments and piping. The resulting savings are enumerated. At the same time, the author lists some of the dangers that may result from over-standardisation.

In the design of its plant, which the Canadian Chemical Company is constructing in Edmonton, Alberta, endeavours have been made to standardise the design of as much equipment as possible.

The plant will manufacture organic chemicals from petroleum, and cellulose acetate from petroleum and wood pulp; in addition, it will spin cellulose acetate into yarn.

The plant is divided into three sections, the petrochemical area, the cellulose acetate area, and the yarn area. Feed stock to the petrochemical plant will be from two sources, liquefied butane and propane from gasoline plants, and recovered gases from Edmonton refineries. A hydrogen sulphide removal unit is required to remove this component from the refinery gas streams before the propane and butane can be fed to the oxidation unit.

The oxidation unit, operating under carefully controlled conditions, uses air as the source of oxygen to produce the following recoverable chemicals: Formaldehyde, acetaldehyde, propionaldehyde, acrolein (the unsaturated form of propionaldehyde), propylene oxide, methanol, acetone and mixtures of heavier aldehydes, oxides, alcohols, and ketones. Two chemical streams leave the oxidation unit, one primarily formaldehyde, the other containing the remainder of the oxidation products.

The formaldehyde-containing stream is pumped to a separate unit, where it is purified to 37 per cent formalin solution for sales or transferred to another unit for conversion to pentaerythritol. The main chemical stream from the oxidation unit is fed to the products purification unit, which is the largest unit in the petrochemical area, containing about twenty-five towers and extractors.

By the employment of straight distillation, azeotropic distillation, extractive distillation, and liquid-liquid extraction, the products of the complex feed mixture are separated into pure products or mixtures of products, which are further purified in a separate specialties unit.

Chemicals produced will be shipped by rail or truck. Liquid products will be handled either in drums or tank cars, while solid products will for the most part be shipped in bags. Owing to the remote location of the plant with respect to some of the larger markets, considerable storage facilities have been provided to permit steady operation of the plant, should delays in tank car movements to or from outside points cause erratic shipping rates.

From the foregoing brief discussion of the petrochemical area it can be seen that refinery type equipment, such as distillation towers, tanks, heat exchangers, pumps, instruments, and piping is primarily required. The cellulose acetate and yarn areas, on the other hand, primarily handle solids, and require a much smaller percentage of refinery type equipment. For this reason, the standardisation programme to be discussed applies primarily to the petrochemical area of the plant.

STANDARDISATION OF LAYOUT AND BUILDINGS.

The first standardisation applied to the petrochemical area was the block layout system. This provides a three hundred foot square block for each unit, with a one hundred foot roadway and pipe lane clearance between blocks. The block system was adopted to provide room for expansion of various sections of the plant without interferences.

All told, there are eight blocks in the petrochemica area. The product purification unit could not be installed in this size block, making it necessary to assign a 300 ft $\times$ 700 ft area to this unit. Generally, the longitudinal axis of the buildings is in the centre of the block, the building being located closer to the south end of the block, to permit extension, if desired, at a later date. Location of the buildings in this manner within the block will permit the removal of any item of major equipment from the block, without interference from other units or utilities equipment.

The second item of standardisation in the petrochemical area is the design of the buildings. The buildings are 48 ft wide and 32 ft high at the eave, with the second floor elevation 16 ft above the first floor. Standard 15 ft bays were selected, to hold virtually all types of equipment required. Most of the building cross-sections are identical with regard to height, width, roof structure, floor loading, and equipment layout. With this design, the drawing, ordering, and fabricating of the structural steel for the buildings was simplified to the maximum extent.

A 24 ft shed is provided along one side to house the bottom portions of the fractionating towers and their reboilers. A 15 ft shed is provided on the other side of the building, to house the ends of the run-down tanks and their transfer pumps. Thus, the operators of the units can carry out their assignments completely indoors. The only outdoor work required will be that of transferring of material from storage to tank cars or from storage to other units.

Overhead vapour lines from the towers will enter the building through the walls of the second floor, where heat exchangers are located along one side of the second floor. This gives clearance on the other side of the second floor for cleaning the tubes, replacing the tubes, or removing the entire heat exchanger. An overhead crane has been provided in the second floor of each building to permit removal of the heat exchangers and other equipment from the building for repairs or replacement.

Because of numerous openings in the sides of the petrochemical buildings, required for the piping to and from towers, it was decided to use a Trafford tile or transite type wall, which can be easily cut. This siding is supplied in standard size sections, which can be easily fitted to the building steel at a low cost. Following the example of some of the other people in the area, a sprayed-on asbestos insulation for the petrochemical buildings is being used.

On the other hand, buildings in the cellulose acetate and yarn areas are made with pre-cast concrete wall slabs, consisting of two inches of concrete, two inches of "foamglas," and two more inches of concrete, held together with reinforcing, and bolted to structural steel framework. Basic differences in type of equipment housed are the reason for different construction.

The ventilating of all buildings presented a serious problem, because of the high freezing point of some of the products and their lachrymatory properties. The combination of these two items required from five to twelve air changes per hour and the maintenance of a reasonable temperature within the buildings. Control rooms are pressurised with heated, outside air, which eliminates the necessity for explosion-proof instruments and electrical controls in these areas. Through the use of transmitters, no chemicals are piped into the control rooms.

On account of the combustible nature of many of the chemicals, there are no trenches in the floors of the buildings. All service piping runs overhead inside the buildings, leaving the sewers and scavenger systems as the only underground piping. The scavenger systems consist of stainless steel underground header systems. From these, any pump leakage and sample bottle washings are collected at a number of central points for returning to the process tanks. While this system is quite elaborate, it is soon paid for by the reduction in losses of products, which range in value from twenty-five cents a gallon to fifty cents a pound.

Standardisation of Storage System.

One of the areas of the petrochemical section of the plant contains most of the storage tanks. Spherical pressure storage tanks are supplied for butane and propane and some high vapour pressure products. Spheroidal-roofed tanks are provided for low vapour-pressure, yet volatile, products, which must be connected to plant vapour recovery systems. Cylindrical pressure tanks are used for small volume high vapour-pressure products, and ordinary cone-roofed tanks are used for the low boiling materials.

All piping in the tank farm is about three feet above ground on concrete sleepers. This permits accessibility to the piping and eliminates the losses of products due to leaks in underground lines. An unused line can be salvaged economically, or an undersized or corroded line can be readily replaced. All tanks containing the same product have their own pump house, thus reducing considerably the amount of interconnecting piping in this area. An additional advantage of this type of installation is that it is impossible for the pumper to open the valves from the wrong tank into the pump for transferring the material to another point.

Standardisation of Heat Exchangers.

Heat exchangers are among the most highly standardised items of the plant. All heat-exchanger tubes are one inch O.D., and are either 20 ft long or some equal division of 20 ft, giving 100 per cent utilisation of the standard 20 ft tube length. The vapour condensers and liquid-liquid exchangers are virtually all 20 ft long. Owing to the rigid specifications of the products, no floating tube sheets are used; instead, expansion bellows have been installed in the shells of units where appreciable expansion will occur. This stems from the fact that it is impossible to eliminate leaks in the floating tube sheets and their gaskets, because of unequal expansion of the bolts and head and tube sheet materials.

This unequal expansion results in over- or under-compression of the gasket at some time during the cycle, giving rise to leaks. With the exception of some of the large standardised units, all condensers and exchangers are drilled for two-pass flow, although many of these are installed with one-pass heads. This design permits changing the number of passes on the tube side by minor changes to the heads, making each tube bundle more readily adaptable to changing conditions.

Thermosyphon reboilers are used throughout the petrochemical section. Generally speaking, the amount of surface required by the thermosyphon type of construction is about one half of that required by the kettle type. A further saving of space is effected because the unit is mounted vertically, close to the tower, and has a much smaller diameter and tube length.

Very little liquid is retained in the reboiler tubes—sometimes a factor where polymerisation might occur with long retention times at elevated temperatures. Experimental work is progressing, which will ultimately lead to the publication of information on these units. The design of the thermosyphon reboilers has been standardised, so as to have 8 in., 12 in., 16 in., 20 in., 24 in., 30 in., and 36 in. diameter bundles, with tube lengths of 5 ft. and 6 ft 8 in. Any reboiler of the same diameter and tube length can be interchanged with any other reboiler of that diameter in the plant.

In future plants, it is planned to standardise further the centre line to centre line dimensions of the nozzles, so that there will be only two or three different ones, making it possible, for instance, to replace a 36 in. reboiler with a 24 in. reboiler, without making any changes in the tower. Owing to the vertical installation of these units and the fact that the liquid level in the tower is maintained at the top of the tubes, there is available sufficient net positive suction head (NPSH) for the operation of the bottoms pumps from the fractionating towers.

Fractionating Towers and Storage Tanks.

About two thirds of the fractionating towers are equipped with sieve trays. Sieve trays differ from bubble trays in that the bubble caps and risers have been replaced by numerous perforations in the tray, to permit passage of the vapours up through the tower. All towers of a given diameter have the same perforating patterns.

If the number of holes required to give stability is different from the number perforated in the tray, those holes not needed are sealed off by the installation of blanking strips across rows of holes. Each tray is perforated, to permit the maximum allowable flow for that diameter tower on any of the products normally processed in the towers.

In order to provide stability to external forces from wind, the towers have been designed with a minimum wall thickness of one quarter inch. The design pressure is then back-calculated, according to the A.S.M.E. code, at a temperature of 400° F. By this method of assigning design pressures, towers are approved for operation at their maximum allowable working pressure, although the actual operating pressure at a given time may be much less. This provides needed flexibility in a plant where changes in market conditions may require changing the service of the tower several times during its life. From previous experience, there are some units in which the service of every tower has been changed at least once.

Aside from the storage tanks, which were standardised to a certain extent, most of the in-process storage tanks are 3 ft by 5 ft, 5 ft by 8 ft, 6 ft by 30 ft, or 8 ft by 30 ft. The two latter are used for product run-down tanks while the others are overhead receivers and surge tanks. Although some price advantage was obtained

by standardising on these sizes, a further saving could have been effected by purchasing standard LPG storage tanks from small manufacturers, who manufacture them on a production line basis at a cost of about fifteen cents per pound. In future, the LPG tanks will probably be used ; these normally come in two sizes, five hundred and one thousand imperial gallons, in place of the 3 ft by 5 ft and 5 ft by 8 ft tanks.

Standardisation of Pumps.

The selection of centrifugal pumps was made by comparing equivalent pumps from several manufacturers, then selecting two manufacturers to supply the main group of pumps, one, the cast iron and steel, the other the stainless steel, pumps. Instead of selecting the most efficient pump for each of the individual services, several sizes of pumps were selected and the one coming closest to the requirements for each service was taken. In this way, the number of different sizes of pumps was reduced by about two thirds, and a saving of about $50 per pump realized in the original purchase price.

In addition, by eliminating a number of sizes of pumps, there is considerable saving in spare parts investment and warehouse space for maintaining the pumps. Of course, the efficiency of pumping was sometimes affected adversely. With the low flow rates and heads required in most instances, however, the difference of a small percentage efficiency is not worth considering, because it amounts to so little in the overall plant power load.

Most pumps are electrically driven, the motor carrying the pump throughout its entire operating range with the impeller size being used. Turbine drives are being provided in two instances : One, to utilise the power from the considerable volume of high pressure vent gas, and the other, to keep the liquids flowing in the event of a power failure.

Most pumps are supplied with mechanical seals, which are interchangeable from one type of pump to another. Less than six seals are being used in the plant on the standardised group of pumps. Only maximum diameter impellers will be stocked, and the plant machine shop will trim them to the required diameters immediately prior to installation. All pumps are mounted for the largest motor which that pump can utilise wtih its maximum diameter impeller. This will permit the changing of service of the pump without remounting the entire pump and motor unit.

Electric motors of 3 hp minimum are used to ensure the operation of the pump if the packing were to become too tight or if maximum flow were suddenly to be required from the pump. A number of vertical pumps has been selected for the tank farm, due to their low NPSH characteristics, which permitted keeping the tanks close to the ground. In one instance, there was insufficient area to install horizontal pumps and vertical pumps were used.

Standardisation of Instruments.

Instruments for the petrochemical section were bought in bulk and given standard classification numbers, so that they can be withdrawn from stores according to classification rather than special requirements. Discussions have been held with numerous companies concerning the use of specialised instruments for various applications, such as boiler control, centrifugal compressor controls, and so on. Virtually all the instrument engineers feel that the use of standard refinery and chemical plant process instrumentation for boilers, compressors, etc., results in better instrumentation for these units, as well as a lower cost.

By the adoption of process instrumentation, a saving of about 50 per cent can be effected. However, in addition to boiler house operators who are not familiar with them, the process instrumentation companies themselves are hesitant about supplying the boiler instrumentation engineering.

Standardisation of Piping.

Before any piping drawings were made, considerable time was spent in setting up standards by which all piping drawings could be made. Various services were given classifications, which specified the type of piping, flanges, fittings, bolts, gaskets, and valves for that classification.

A number of valves was eliminated because they were not built according to standard face-to-face dimensions. Others were eliminated because of previous unsuccessful experiences with them, and still others because no experience at all existed with them. Further standardisation was effected by the preparation of standard drawings for motor valve installation, steam traps, flow transmitters, and other installations which would be repeated numerous times during the construction.

Although considerable time was spent in preparing the piping standards, it was more than made up when the time came to prepare approximately six hundred piping drawings with any semblance of standardisation of materials in them. By referring to the mechanical flow sheet, which noted the line size and classification, no further information was required by the piping draughtsmen and layout men to prepare the drawings and take off the materials for that line. With this type of standardisation, bulk orders were issued to cover the piping for the entire petrochemical area several months before the drawings were actually ready for the take-off. Even with these precautionary measures, the delivery of stainless piping and fittings has been a serious bottleneck in the construction of the plant.

Advantages and Dangers.

The foregoing gives a brief description of some of the ways in which the design and construction of the plant has been standardised. It is believed that this programme has resulted in :

(1) Savings in engineering, due to ease of preparing and checking drawings.
(2) Savings by facilitating bulk orders.
(3) Savings in training of installation and maintenance crews on different makes of equipment.
(4) Savings in the reduction of the number of spare parts required.
(5) Savings in the training of operators and the resulting improved operations from simplified and standardised equipment.
(6) Increased versatility and flexibility of equipment, a very important factor in the chemical business, on account of the ever-changing requirements of the chemical market.
(7) A more attractive plant.

However, at the same time that the Company is attempting to standardise plants, there are certain dangers arising from over-standardisation. Some of these dangers are :

(1) Failure to keep up with the progress of new developments. The steam locomotive is a good example of lack of progress, due to over-standardisation. Another good example is the plumbing code, which in outdated many years, according to modern plant piping practice.
(2) Unless care is taken, too many safety factors will creep into standardised equipment, resulting in over-design, which can destroy the economic advantage of standardisation.
(3) By retaining old standards, advantages of new equipment and methods are sometimes not taken.
(4) If standardisation is overstressed, the initiative in younger engineers is killed and eventually the engineering group of the Company becomes stagnant.

GERMANY

Pulsating Firing of Steam Boilers

By F. H. REYNST. (From *Mitteilungen der Vereinigung der Grosskesselbesitzer*, No. 24, June 1953, pp. 419-436, 19 illustrations.)

In Part I of this article, published last month, the development of pulsating burners was traced and their operational characteristics explained. In this second instalment, the practical application of these burners to steam boiler plant is discussed, with particular reference to the advantages obtainable by incorporating an air turbine in the system.

PART II.

APPLICATION TO BOILER PLANT

The gain in pressure, as well as the oscillation energy, of a pulsating burner will yield distinct advantages in both the design and operation of steam boilers. In this connection, combustion chambers with diffusers are preferable to valve-controlled resonator tubes for several reasons, among which may be mentioned the following: They do not require valves, they eliminate losses due to control gear, there is no reduction in negative pressure amplitudes, they are less liable to faulty operation, and they produce higher pressure and oscillation energies.

Even a relatively small pressure gain of 1000 mm water gauge, obtained with the by no means perfect experimental burner with diffuser described in Part I, would be sufficient to operate the boiler without induced draught or forced draught fans. The boiler furnaces would, of course, become pressurised to some extent, to force the gases through the boiler against the flow resistance of the heating surfaces. However, boiler designs have already been developed and tested, which are able to withstand several hundred mm W.G. The remaining pressure gain is available for drawing in the air through the air preheater. The advantages to be derived from the corresponding reduction in capital costs and from the improvement in thermal efficiency of the power station, as a result of the elimination of fan drives, are obvious. However, as will be shown in the following, additional advantages can be obtained by a still greater gain in pressure in the combustion chamber.

The initial stage of the cooling of the combustion gases takes place in the burner, the walls of which are water cooled; however, although the heat transfer from the gases to the water is approximately double the usual rate, owing to the pulsating combustion and the high temperature resulting from the highly concentrated heat release, the temperature of the gases leaving the chamber is very high; in fact, taking into consideration the ash content, these gases cannot be brought immediately into contact with the convection surfaces of the boiler. For this reason a radiation chamber must be provided between the burner and the heating surfaces. However, to utilise the pulsations for improving the heat transfer on these, as well as on the secondary, heating surfaces, the radiation chamber must be combined with the pulsating combustion burner, so that the gases also pulsate in the radiation chamber. How this can be achieved is shown in Fig. 7, where it will be seen that the inlets, as well as the outlets of this radiation chamber, are situated at the points of maximum velocity of the standing wave, as the pressure at these points is constant.

In conventional boilers, heat transfer in the radiation part takes place almost entirely by radiation, and in a very small measure only by convection. Radiation is wholly determined by temperature and cannot therefore be influenced by pulsations. However, as already mentioned, heat transfer by convection is very considerably increased by pulsations which disturb the boundary layers. In consequence, compared with conventional boilers, a much smaller radiation part will be required for the same total heat transfer.

If sufficient space is available, the convection surfaces can also be installed in this section of the boiler. The required convection surface will be reduced still more than the radiation surfaces. As has been shown by experiments, the propagation of pulsations will be affected by the tube nests only to a very minor degree. The size of this section can be increased sufficiently to permit the installation of heat transfer surfaces adequate for any desired flue gas exit temperature.

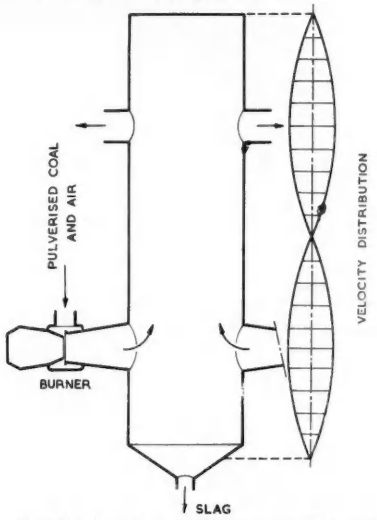

Fig. 7. **Combination of pulsating burner with radiation chamber.**

This may be done by dimensioning the chamber for three or more half-waves, and not for two half-waves, as shown in Fig. 7. As the frequency of the burner is constant, this part of the boiler requires a correspondingly greater volume.

Additional advantages can be obtained by operating two pulsating sections in "push-pull", either by connecting in parallel the exhaust ducts of two arrangements, such as those shown in Fig. 7, or by designing the boiler according to Fig. 8. This latter arrangement has the particular advantage of being acoustically confined.

The ash precipitates mainly in the nodal points of

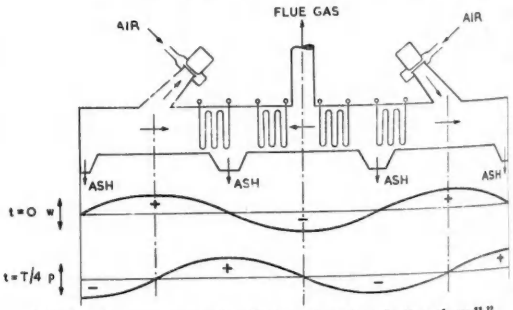

Fig. 8. **Arrangement of radiation chambers in "push-pull," with corresponding velocity and pressure diagrams.**

the velocity distribution, where there is only a low velocity of basic flow. The ash outlets are therefore installed at these points (Fig. 8). To improve ash removal, the gas velocity at the exit from the burner can be used to impart a swirl to the gas in the dead ends of the secondary sections, so that this space can be used as a fly-ash precipitator.

With regard to the control of a steam boiler with pulsating firing, the following methods may be applied :

(1) If several burners are used at each gas inlet, these can be shut down individually (step regulation).
(2) By altering the gap between chamber and diffuser, a varying quantity of pulverised fuel-air mixture can be drawn in. Any surplus of mixture will be burnt in the diffuser (quantity regulation).
(3) By varying the length of the pulsating column of the burner, the natural frequency is changed and, in consequence, different harmonics are induced in the secondary sections (frequency regulation).
(4) A combination of the above methods.

Gas Turbines with pressure-producing combustion chamber.

For utilising the still higher pressures which can be produced by a pulsating combustion chamber, turbines must be used, as shown in the following :

If the "resonator efficiency" is defined as the percentage of heat of combustion converted into adiabatic pressure drop (i.e., gain in total pressure) between entering and leaving the combustion chamber, the thermal efficiency of the gas turbine can be expressed by means of the entropy diagram as a function of the resonator efficiency[1], as indicated in Fig. 9. Here, A-B-C-D represents a conventional constant-pressure gas turbine cycle, and A-G-E-F the gas turbine cycle, with the same gas temperature at the turbine inlet, but with a combustion chamber, to increase the pressure. It is assumed that the combustion chamber operates without heat loss and with excess air. It is further assumed that the compressors of the two turbines are similar. The turbine operating on the compressed gas principle must then be designed for a pressure exceeding

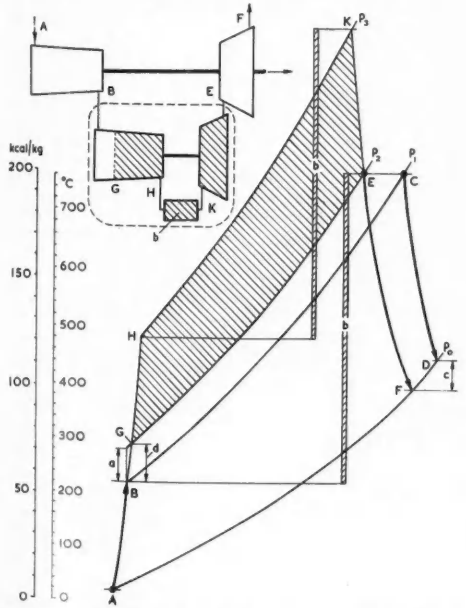

Fig. 9. **Entropy diagram of the compressed gas process.**

that of the constant-pressure turbine by the pressure gained in the combustion chamber. The difference between the adiabatic heat drops C-D and E-F (distance *c*) represents the gain in output of the compressed gas process, compared with the constant-pressure process. In both cases, the same amount of heat is developed per kg of air (shaded distance *b*). During the heat release process, pressure p_1 remains constant in the case of the constant pressure process, whilst in the case of the compressed gas process, it increases to p_2. It is possible to consider the compressed gas generator B-G-H-K-E as consisting of a hypothetic gas turbine G-H-K-E driving a hypothetic compressor B-G. In the combustion chamber of this hypothetic gas turbine in turn, heat, represented by *b*, is developed. The adiabatic pressure increase in the compressed gas generator is marked *a*.

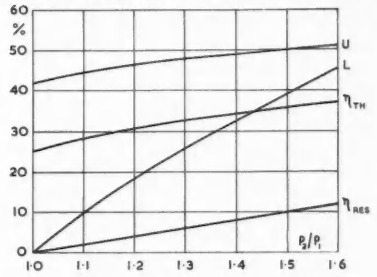

Fig 10. **Characteristics of the compressed gas process, as a function of pressure increase.**

η_{res} = resonator efficiency
η_{th} = thermal efficiency.
L = percentage increase of useful output
U = useful turbine output as a percentage of total output.
Assumptions : Turbine inlet temperature = 777° C ;
adiabatic compression efficiency = 90% ;
adiabatic turbine efficiency = 85% ;
delivery pressure of compressor = 6 atm abs ;
no regenerator.

The thermal efficiency of the compressed air generator can be expressed by $(d/b)\ (a/d) = a/b$, the output of the hypothetic turbine being equal to the input of the hypothetic compressor. The ratio a/b is called the resonator efficiency, if the compressed air generator operates on the principle of the combustion resonator. Point *E* in the entropy diagram can then be moved towards the left, and the corresponding distances *c* and *a* can be read from the diagram for different positions of *E* ; it will be found that these distances are almost equal. It can therefore be stated with sufficient accuracy that the thermal efficiency of the compressed gas process equals the sum of the thermal efficiency of the constant-pressure process and of the resonator efficiency. Fig. 10 shows the characteristic data of the compressed gas process as a function of the ratio p_2/p_1, and clearly indicates the advantages derived from pulsating, compared with constant-pressure, combustion.

Steam boiler with air turbine.

It has been stated that the kinetic energy of gases in a furnace may amount to one half of the turbine capacity and that, as this energy is being "down-graded" to heat, special measures should be taken to utilise it in the form of mechanical energy for driving an additional electric generator. However, as long as no method is known for complete fly-ash elimination, it is not feasible to use this method, owing to the erosion to which the turbine would be subjected. Consequently, pulverised-coal fired boilers will be designed for essentially atmospheric pressure in the furnace. However, by designing the resonator tube in the shape of a diffuser, part of the kinetic energy of the combustion gases is transformed into potential energy, and the combustion chamber assumes the role of an ejector pump drawing air from a container. This container, through which all combus-

tion air passes, is therefore kept at sub-atmospheric pressure during operation and the pressure difference between this and atmospheric pressure can be utilised to operate an air turbine driving an electric generator. This turbine then operates as a pneumatic, and not as a heat, engine. As air only is used in the turbine, erosion does not occur. The entropy diagram corresponding to this mode of operation is shown in Fig. 11. Because of air expansion in the turbine, ice formation may occur, and to avoid this, it is advisable to preheat the air up to, say, 400° C; no gain in efficiency can be achieved by a higher initial temperature, as the turbine does not operate as a heat engine.

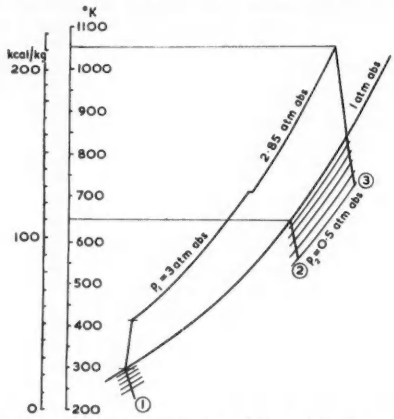

Fig 11 **Entropy diagram of air turbine process.**

p_1 = pressure at air compressor outlet.
p_2 = pressure at turbine outlet.
(1) = air turbine, without air preheating.
(2) = air turbine, with air preheating.
(3) = air turbine, with pre-compression and air preheating.

The installation of the air turbine does not have an adverse effect on the efficiency of the steam cycle. Each calorie lost in the furnace through the effect of the air turbine is fully recovered in the form of mechanical energy. Even though the original output of the steam turbine will be reduced by the use of an air turbine, the sum of the outputs of the steam and air-turbines will exceed the original output of the steam turbine. Thus, the overall efficiency of the plant will be increased.

It is possible, not only to pre-heat the combustion air, but also to pre-compress it, as, for a given sub-atmospheric pressure, a higher resonator efficiency can be achieved. The corresponding entropy diagram is shown in Fig. 11, point (3), where it will be seen that the net output of the turbine (in this case the total heat drop utilised in the turbine less the drop in the compressor) exceeds the output of the two preceding cases, shown at points (1) and (2).

Fig. 12 shows diagrammatically the combined steam-air turbine plant with pre-compression. This is reminiscent of the hot-air turbine designed by Stolze in the last century, and of a recent suggestion by Karrer[2]; it also has points in common with the locomotive air-turbine, with pulverised coal combustion after the turbine, under development in Canada[3]. In these machines, as in the described arrangement, the compressed air is not heated by direct combustion, but combustion takes place in the expanded, though still very hot, air after the turbine, and the heat is transferred by a heat-exchanger from the flue gases to the compressed air. However, the special feature of the plant shown in Fig. 12 is the pulsating combustion in a burner, which itself produces sub-atmospheric pressure.

Whether it would be more economical to build a combined air-steam power station with or without air pre-compression, i.e., whether to equip the combustion

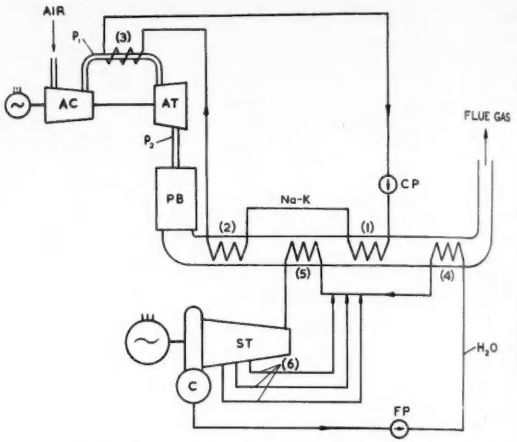

Fig 12 **Diagram of combined steam-air plant, with indirect air heating.**

AC = air compressor.
AT = air turbine.
PB = pulsating burner.
ST = steam turbine.
C = condenser.
FP = feed-water pump.
CP = circulating pump.
Na-K = sodium-potassium-eutectoid heat exchanger.
(1) = first stage of *Na-K* heater, with low temperature difference.
(2) = second stage of *Na-K* heater, with high temperature difference.
(3) = air heater.
(4) = feed-water preheater.
(5) = steam boiler, with superheater.
(6) = bleed points for feed-water heating.
p_1 = pressure at compressor outlet.
p_2 = sub-atmospheric pressure at burner inlet.

chamber with an air turbine only, or alternatively with a turbo-compressor, cannot be decided on the basis of any possible improvement in the thermal efficiency alone, which, in the former case, may be of the order of 5 per cent, and in the latter 7·5 per cent. The argument against the use of air pre-compression is first of all the need for a heat exchanger to transfer almost 40 per cent of the total heat content of the fuel from the flue gases to the compressed air at a very high temperature, with the least possible loss of pressure. This is, however, practicable only if the most recent developments[4] in the field of heat exchangers are applied. The diagram in Fig. 12 assumes the use of a heat exchanger employing sodium-potassium-eutectoid, a liquid non-boiling metal with favourable thermal properties. This can be used with advantage where the heat supplying surfaces are remote from the heat absorbing surfaces, and this property would be particularly applicable in this case, as it would permit the flues of the boiler and the air ducts of the turbo-compressor to be separated from each other, so that they can be designed for the most advantageous conditions for oscillation, as well as gas flow.

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The Design of Large Steam Turbines in Czechoslovakia

By J. Bečvář, J. Klima, and J. Snížek. (From *Strojirenstvi*, Vol. 2, No. 10, 1952, pp. 435-445, 20 illustrations.)

Even before the first World War, Czechoslovakia was an important supplier of prime movers for electricity generation, not only for her own requirements, but also for export. The equipment described in this article, which deals with large steam turbines for central power stations, was manufactured by the Lenin works in Pilsen and the CKD-Stalingrad works in Prague. It is interesting to note that, although no mention of it is made in the original paper, the Lenin works are obviously identical with what used to be known as the Skoda works.

By comparison with smaller units, high-output steam turbines have a higher efficiency, require less materials per unit output, reduce the time of construction, and occupy less space in the powerhouse, thereby lowering building costs. Furthermore, they require less personnel and reduce maintenance costs.

For instance, two single-cylinder turbines, each of 25 MW output, require for foundation work alone about 42,500 cu ft of ferro-concrete more than one two-cylinder turbine of 50 MW output, equivalent to a saving of about 4300 sq ft of floor space. Furthermore, for the same working conditions, the efficiency of the two-cylinder turbine would be about 3 per cent higher than that of two single-cylinder turbines ; also, the generator efficiency would be better by 0·5 per cent and the number of personnel would be halved.

Considering large turbines for power station duty, operating at 3000 rpm, the possibilities of increasing output are tied up with the increase in flow areas of the last stages, which have to pass large volumes of steam. In addition, some difficulties arise in connection with the regulating stage, the running blades of which are subjected to considerable and varying forces, especially with partial loads at group regulation. These forces increase with increasing output and, for reasons of economy, must be sustained at the highest possible pressures and temperatures.

LARGE STEAM TURBINES FROM THE LENIN WORKS, PILSEN.

In 1950, the Lenin works delivered a 40 MW turbine, running at 3000 rpm, for electricity generation, the steam conditions being 1790 psia and 896 to 932° F. In this two-cylinder turbine, with a single-flow low-pressure cylinder, the steam is reheated between the cylinders by the boiler flue gases to 788° F. By using this technique, instead of reheating with live steam, the thermal efficiency of the cycle is improved and wetness of the steam in the last stages of the low-pressure cylinder is considerably reduced, with consequent increase in blade life and efficiency.

The high-pressure rotor consists of a Curtis wheel as a regulating stage, and a row of impulse stages ; the shaft and discs are integrally forged from one piece, and the discs of the low-pressure rotor are keyed to the shaft.

Nozzle control governing consists of four valves and two overload-valves. There are two valve-chests, bolted to the housing, resulting in temperature differences across the chests lower than those which would be obtained with integrally cast components. To prevent the turbine from overspeeding, there are, on the low pressure cylinder, two valves which, in the case of substantial unloading, reduce the entry of steam from the reheater to the low-pressure cylinder, and, in the case of complete unloading, close entirely. These valves are hydraulically controlled from the governor drive on the high-pressure part. In addition to the centrifugal governor, this turbine is provided with an inertia regulator, which operates before the centrifugal governor comes into action, and at a certain overspeed closes both the live steam valves and the valves on the low-pressure cylinder. The reheater is protected from any undue pressure rise by a safety valve. Moreover, the steam pipes leading from the reheater to the turbine are equipped with quick-closing valves, actuated by the safety governor of the turbine. The horizontal centrifugal governor is driven from the main shaft by spur gears, and acts on an oil piston. A gear pump underneath the front bearing provides oil for both regulation and lubrication.

The turbine has four non-regulated bleed-points for heating the condensate to 381° F. Interposed between the second and third bleed point is an evaporator for an output of 10 tons/hour of distillate. Excess steam from the low-pressure steam services of the power station is fed into the turbine after the ninth low-pressure stage, at a pressure of 23 psia. This was the first Czech-built turbine with flue-gas inter-cylinder reheating. As, with such a turbine, the heat consumption is reduced

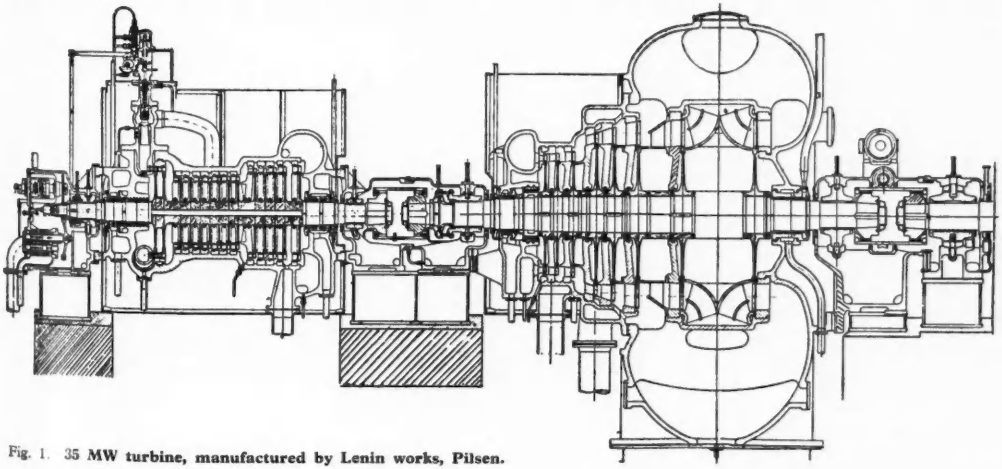

Fig. 1. **35 MW turbine, manufactured by Lenin works, Pilsen.**

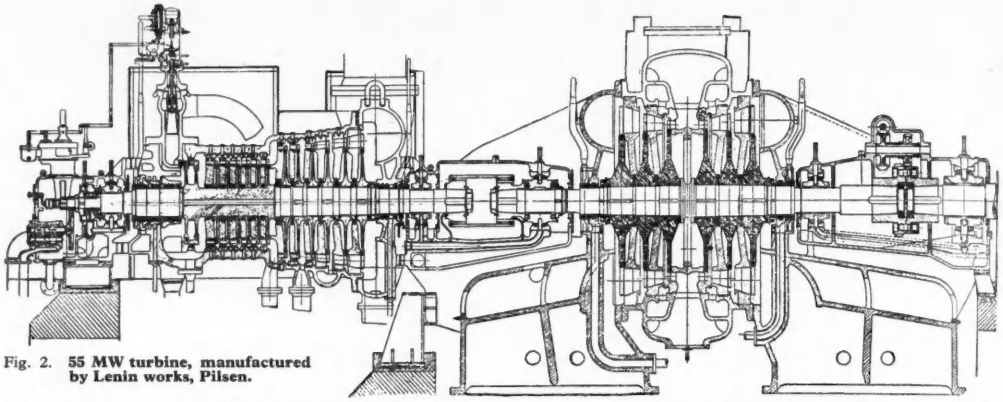

Fig. 2. **55 MW turbine, manufactured by Lenin works, Pilsen.**

by 4 per cent or more, it is possible that Czech power-stations will be equipped with units of this type, of 50 MW and higher.

Fig. 1 shows one of a number of two-cylinder turbines, already delivered, with an output of 35,000 kW, steam pressure 937 psia, temperature 905° F running at 3000 rpm. This turbine is not of particularly recent design, and the flow in the last stage of the low-pressure cylinder is divided. Otherwise, in principle, it is of similar construction to the one already described, though it is not provided with an inertia regulator. Fig. 2 illustrates one of a number of turbines recently produced by the Lenin works for an output of 55 MW at 3000 rpm. The inlet steam conditions are 980 psia at 914° F, maximum conditions 1150 psia at 950° F; cooling water temperature for the condenser is 77° F.

Apart from the aforementioned two-cylinder turbines, the Lenin works have concentrated their attention on large single-cylinder turbines, a typical example of which, shown in Fig. 3, is for 35 MW at 3000 rpm, and for the following inlet steam conditions: 809-923 psia at 914°-950° F; cooling water temperature, 81° F. Insofar as output is concerned, this is the largest single-cylinder turbine manufactured anywhere in Czechoslovakia. The turbine has a Curtis wheel and a number of impulse stages. The wheels of the velocity compounded impulse stage and those of the next four stages are integrally forged with the shaft, the remaining wheels being keyed to the shaft. A comparison of this turbine with two-cylinder turbines of equal output reveals the great simplicity of design, and the saving in materials and space required, these, however, being obtained at the expense of a somewhat lower efficiency.

The Lenin works have now standardised their turbines for large outputs, based on 25 MW single-cylinder units and 50 MW two-cylinder units, both for 3000 rpm and steam conditions of 1278 psia at 932° F, and a cooling water temperature of 59° F. The low-pressure cylinder of the 50 MW-turbine is of the two-flow type. It is planned to extend this range to single-cylinder single-flow turbines of 50 MW output, and to two-cylinder turbines of 100 MW output, both at 3,000 rpm.

THE 50 MW CONDENSING TURBINE OF THE CKD-STALINGRAD WORKS, PRAGUE.

The steam turbine department of CKD-Stalingrad received an order in 1948 for the construction of a 50 MW turbine for the central power station at Trebovice. At that time, this output and the steam conditions (1562 psia at 986° F) were the highest reached in Czechoslovakia, and this was the first turbine to be used with a hydrogen-cooled generator. Amongst other conditions, speedy starting and the greatest possible automatisation of operation and attendance were stipulated.

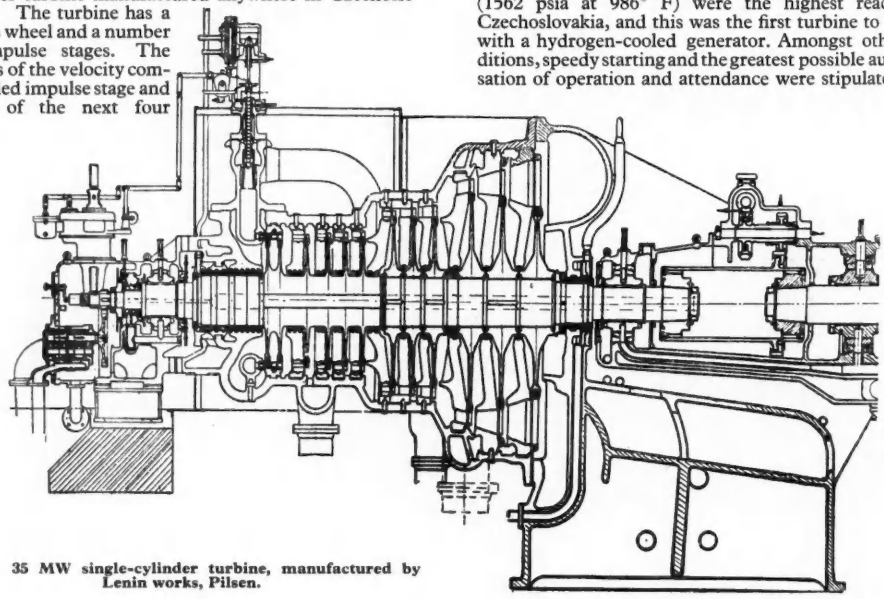

Fig. 3. **35 MW single-cylinder turbine, manufactured by Lenin works, Pilsen.**

The turbine was of the two-cylinder, reaction-bladed type, with one controlled stage. The total expansion was subdivided as follows :—

Curtis stage : 1420-710 psia, two velocity-compounded rows.

High-pressure cylinder : 710-99 psia, 72 stages.

Low-pressure cylinder : 99-8·5 psia, 34 stages.

The last stage is designed on the vortex theory and employs a " vortex " blade of about 18⅛ in. in length, utilising a pressure drop of from 4·3 to 0·85 psia, and producing 4000 kW. The remaining stages have a " bulb head " profile and are unshrouded.

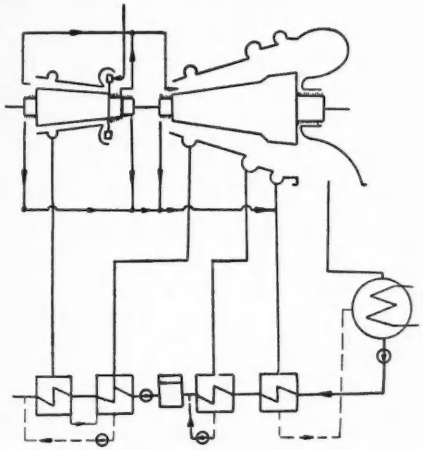

Fig. 4. **Schematic diagram of 50 MW turbine, manufactured by CKD-Stalingrad works, Prague.**

As shown schematically in Fig. 4, this 50 MW turbine has four non-controlled bleed point for feed water heating to 392° F. The guaranteed consumption figures, considering the heat energy as power at generator terminals, are as follows :—

Steam consumption : 8·23 lb/kWh.

Heat consumption : 9200 BTU/kWh.

A major problem presented itself in the design of the high-pressure casing and valve chest. If the standard system, with a single-seat valve in a valve chest with removable cover, had been used, the side walls of the chamber would have had to be stressed to 28,400 psi. This would have exceeded the allowable stress for the chrome-molybdenum steel casting available. Consequently, a closed valve chamber of circular cross-section was designed, as shown in Fig. 5.

Similarly, a new design of nozzle segment had to be worked out. To avoid deformations due to temperature differences ahead of and past the nozzles, and for fastening the nozzle segment (1) to the valve chest (3) safely, a separate extension piece (2) was provided (see Fig. 5). The nozzle segment (1) is forged in one piece, the outer periphery of which is provided with as many radially bored holes as there are nozzles. The nozzles proper are machined and hand-finished. At its outer periphery, the nozzle segment has a flange. This flange and the extension piece (2) to which is bolted, are ground. Thus, there can be no leakage between segment and extension piece. The extension piece and the valve chest have flanges which lie in a plane parallel to the turbine axis, so that they and the turbine casing on which they are seated can be accurately faced. This enables the making of leak-proof joints without resorting to special operations. The material of the nozzle segment has a coefficient of thermal expansion almost identical with that of the material—a special chrome-molybdenum steel—from which the extension

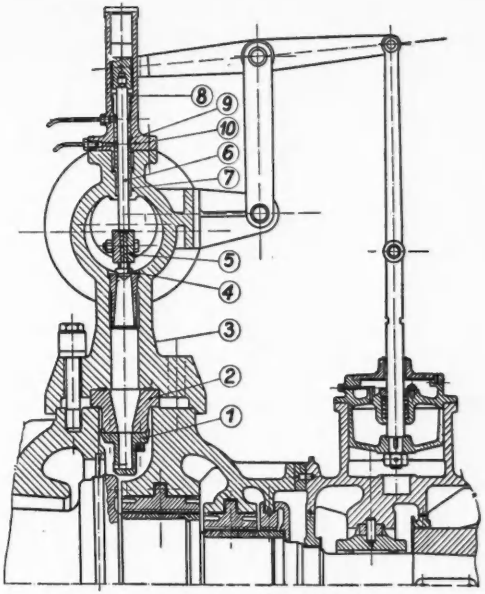

Fig. 5. **Nozzle control valve of 50 MW turbine, manufactured by CKD-Stalingrad works, Prague.**

piece and the valve chamber are cast. This prevents mutual displacement of these parts by thermal deformations.

The conical valves (4) are held by a lifting bar (5), which is longitudinally split and held together by screws. The valves and the lifting bar are placed in position through the steam inlet branch at the side of the valve chest. Two lifting spindles (6) are introduced from the top of the valve chest and held in the lifting bar by bayonet grips. Two nitrided bushes (7) and (8) guide the valve spindle, and a gland (9) is provided in the flanged spindle cover. The gland consists of two nitrided bushes, one of which has a play of 0·004 to 0·006 in. between its bore and the spindle, while the other has play between its outer diameter and the spindle cover bore. Steam is led off at a neck (10), where the two gland bushes are kept separated. This arrangement of the control valves has the advantage that it is necessary to provide glands for only two spindles, although there are six valves. Moreover, these spindles are in motion at every control impulse ; thus, there is little likelihood of the spindles sticking. An additional advantage is that only one servomotor is required.

Another design problem was the exhaust casing. With leaving speeds not exceeding 328 fps, the flow area required was 75 sq ft, and at full vacuum the load on the casing was 65 tons. To support such a load on widely-spaced pedestals would have introduced excessive bending of the casing. It was, therefore, decided to have the exhaust casing split into two branches. Dismantling the exhaust and condenser would have presented difficulties on account of inaccessibility. This difficulty was overcome, and a tight joint was obtained, by inward flanging of the condenser. The turbine coupling was located in a completely enclosed space, to eliminate the possibility of ignition of oil vapours.

Still another problem was the requirement for automatic control of the shaft gland sealing steam. Pressure control was employed, taking its impulse from the gland steam supply pipe. Each gland has independent control. Essentially, this system, shown in Fig. 6, consists of a pressure regulator and a regulating device.

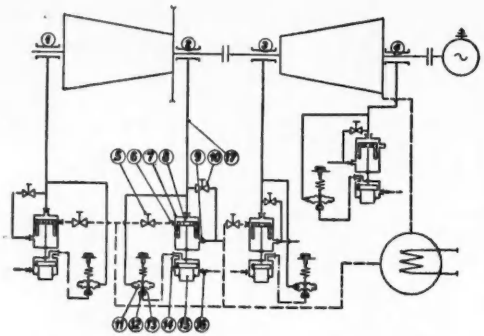

Fig. 6. **Automatic gland control on 50 MW turbine, manufactured by CKD-Stalingrad works, Prague.**

Each gland has in its circuit a regulating system (7) governed by the pressure regulator. The pressure impulse for the regulator is taken from the pipe (17) connecting the system with the gland. The regulating slide (8) moves the differential piston (15) of a servomotor. Pressure oil flows through an opening in piston (15) and through an orifice (14) to a nozzle (12) in the regulator. The flow through the nozzle is controlled by a needle (13) which is connected with diaphragms (11) and is spring-loaded. Spring load is adjustable by means of a hand screw. When starting up, there is no steam in pipe (17), so that the spring load moves needle (13) away from nozzle (12). Thus, oil flows through the nozzle, the pressure above piston (15) drops, and the piston begins to move upward. In its upward move, slide (8) clears the steam inlet opening (9) to the cylinder (7). The steam entering the cylinder passes through an opening in slide (8) and is led through pipe (17) to the gland. The opening (6) in the cylinder is now closed by the slide. As soon as the steam pressure in pipe (17) reaches the pressure at which the force exerted by diaphragms (11) overcomes the spring load, needle (13) closes nozzle (12) and traps the oil above the piston of the servomotor; the oil pressure, therefore, rises and begins to move piston (15) downward. Thus, slide (8) also moves downward, and closes the steam inlet (9). By turning the hand screw, the spring load can be so adjusted as to give the steam in pipe (17) the pressure required for gland sealing.

After the turbine has started, the pressure in pipe (17) begins to rise, and the pressure regulator begins to close the steam inlet opening (9), until it is fully closed. Now, however, the upper edge of slide (8) begins to free the opening (6), which is connected with the condenser and thus steam is sucked away from the gland. By this method, a constant pressure is maintained in pipe (17), and also in the gland. In case of malfunctioning of any part of this control system, the operation of the turbine is unaffected, as manual control of the gland steam is also provided. In such a case, the spring must be completely freed, so that needle (13) closes nozzle (12), when piston (15), together with slide (8), moves downward, and fully closes steam inlet (9). The packing of the gland with steam can now be controlled by means of the hand valve (10) or for sucking away gland steam by hand valve (5). The pressure controls of all the glands are mounted in a common casing near the turbine. In future, all large turbines in Czechoslovakia will be fitted with this automatic gland control system.

The requirement for quick starting of the turbine necessitates measuring the axial elongation of the rotor relative to the casing, this being most pronounced in the rotor of the high-pressure part. The

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U. S. A.

Spindle Drag Pump for Viscous Liquids

By R. A. STRUB. (From *Machine Design*, Vol. 25, No. 7, July, 1953, pp. 149-151, 4 illustrations.)

PUMPING small quantities of viscous fluids at pressures of 10,000 to 30,000 psi is ordinarily done with piston pumps which, when designed for use with viscous fluids, are complicated. Mechanical parts such as pistons and valves are subjected to high alternating stresses and require costly maintenance work. Furthermore, the pulsating nature of the discharge may be objectionable because of possible fatigue failure of piping and the need for regular flow. The latter is often highly important in certain chemical processes where it is necessary to inject viscous fluid into the process stream of a high-pressure synthesis unit.

The spindle drag pump, Fig. 1, is a new type of high-pressure pump for viscous fluids. Simple in design and requiring little maintenance, it is a rational approach towards overcoming the disadvantages of piston pumps in this type of service.

Basically the pump is an extruder. A spindle, rotating in a sleeve at a speed which may reach several thousand revolutions per minute, drags the viscous fluid toward the middle of the pump by the combined action of the rotation and of two shallow helical grooves with opposed threads ground along each half of the spindle. Suction takes place at each end, where leakage is prevented by simple low-pressure seals. Fluid leaves the pump at the middle through a single high-pressure line. Since each half of the spindle pump is identical, it is completely balanced axially and no thrust bearing is required.

Heat generated by the shearing of the viscous fluid

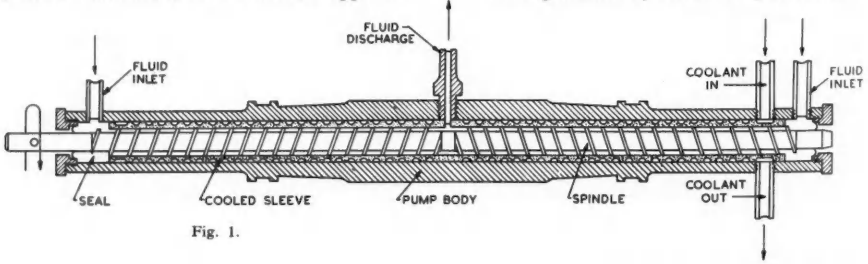

Fig. 1.

in the clearance between the spindle and its bushing is carried away by a coolant, which flows from one end of the pump to the other and then back, in a double helical groove cut in the periphery of the sleeve. A heavy water jacket forms the pump body. If necessary, the spindle can be made hollow and can also be cooled.

Construction.

The pump is built entirely from commercially available tubing, thus reducing the cost of machining. A bronze sleeve with a double helical cooling groove is a shrink fit in the heavy pump body. The spindle diameter is $1\frac{3}{8}$ in. and its overall length is 42 in. It is driven by an elastic coupling through an overload shear pin, which fixes the axial position of the spindle with respect to the pump body.

It was found that long holes could be machined accurately by using standard boring bars and honing tools. Small bows of a few thousandths of an inch have been found acceptable because of the high flexibility of the spindle.

The pump has the inherent advantages of being simple and requiring low maintenance. A similar pump operated for several thousand hours before it was necessary to replace the spindle. Wear of the spindle or the bushings can be compensated by electrolytic plating of the spindle.

Design.

Spindle drag pump design is based on the theory of screw extruders[1, 2]. Assuming a thread width of b in., a spindle diameter of D in., and a thread depth of h in., for a uniform shallow thread profile the pressure P is related to the output Q (cu in. per sec) by the equation

$$P = \left(\frac{3 \pi D N}{h^2 \tan \psi} - \frac{3 Q}{\pi \beta h^3 D \sin^2 \psi} \right) L \mu \quad .. \quad (1)$$

where t = pitch, L = total length of threaded sections of spindle, N = speed of spindle rotation [rps], $\beta = b/t$, μ = viscosity of fluid in the thread [lb-sec/sq in.], and ψ = helic angle ($\tan \psi = t/\pi D$).

Leakage past flights diminishes the pressure generated by the pump[2]. From the test results the average viscosity, including the influence of leakage, can be calculated by using eq. (1).

The power absorbed is given by the relations[2]

$$Z_1 = \pi^3 D^3 N^2 \frac{L}{t} \frac{e}{\delta} \mu_f \quad .. \quad .. \quad (2)$$

$$Z_2 = \pi^3 D^3 N^2 \frac{L}{t} \frac{b}{h} \mu \left(4 - \frac{3 Q}{Q_{max}} \right) \quad .. \quad (3)$$

where Z_1 = power dissipated in clearance, Z_2 = power absorbed in threads, μ_f = viscosity of fluid between flights and sleeve, e = flight width, and δ = radial clearance.

Viscosity μ_f is generally lower than viscosity μ because in the clearance the fluid is submitted to a more intense shearing, which leads to greater heat dissipation.

The potential energy contained in the fluid at discharge corresponds to a power $Z_3 = PQ$. The difference between the total power absorbed, $Z_1 + Z_2$, and Z_3 corresponds therefore to the energy to be carried away by the coolant.

In the previous equations, the viscosity to be introduced is difficult to predict. It is generally a function of the working pressure, of the speed of rotation, and of the intensity of cooling. Proper values of the average viscosity to be used for a new design of spindle drag pump can be found experimentally from a laboratory pump by using eq. (1).

Theoretical work has been carried out in an attempt to correlate the helix angle ψ to the thread depth h, for optimum pump design. Although several combinations of speed, helix angle, and thread depth are possible, it has been found that the following equation is a good guide for relating the different variables :

$$\tan \psi = \frac{2 Q}{\beta \pi^2 D^2 N h} \quad .. \quad .. \quad (4)$$

The length of the pump is then determined by eq. (1).

Test Results.

An extensive test program has been carried out to find the influence of the different factors affecting pump design. A spindle 11 in. long and $\frac{3}{4}$ in. in diameter was spun at speeds varying from 1000 to 5000 rpm in a water-cooled bronze sleeve. Thread depths from 1 to 6 thousandths of an inch and pitches from $\frac{1}{2}$ to $1\frac{3}{8}$ in. (helix angles from 12 to 30 deg.) were tested. The radial clearance was of the order of 0·0005 in.

Test results with different oils are summarised below. The conclusions have been found to be generally valid also for a larger spindle pump, $1\frac{3}{8}$ in. in diameter by 34 in. in length :

(1) The output at no pressure varies proportionally with speed and thread cross-section.
(2) At constant flow of the coolant, the maximum pressure at no flow is nearly independent of speed within a range of 1000 to 3000 rpm, with a maximum at about 2000 rpm.
(3) Maximum pressure at no flow is obtained for thread depths of from 0·002 to 0·004 in.
(4) Power absorbed increases with the discharge pressure and speed. For temperatures of the coolant from 10° to 25° C, the power absorbed is nearly proportional to speed.
(5) If the cooling intensity is increased, the pressure or the output is raised markedly. This indicates that flow regulation of the pump can be accomplished by controlling the cooling system.

No great advantage was obtained by the use of double threads, either with respect to output or to pressure generated, although in some other applications heat transfer is increased by a larger number of threads in parallel. Furthermore, for optimum design, it is best to use a constant pitch along the spindle[2]. Flight width has been found to be non-critical, but must be large enough to provide sufficient bearing surface.

Performance.

A large spindle drag pump designed to deliver 200 cm³/min of oil at 20,000 psi discharge pressure at 1750 rpm and, at an average coolant temperature of 20° C, has the pressure-flow characteristics shown in Fig. 2.

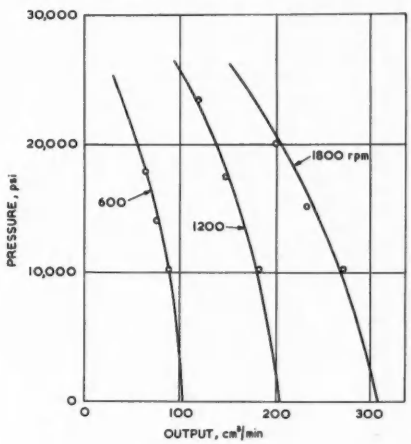

Fig. 2.

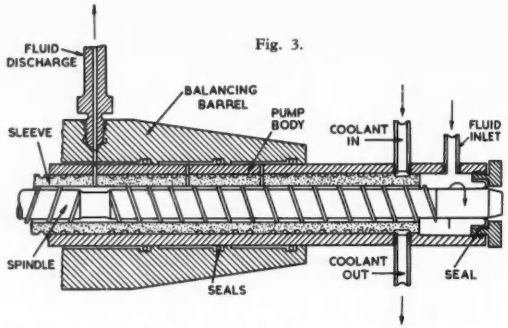

Fig. 3.

Curvature of the characteristics is partly due to the expansion of the bore under the high discharge pressure. This leads to greater clearances and therefore to greater leakage.

PROPOSED DESIGN FOR HIGHER PRESSURES.

A proposed design for pressures in excess of 30,000 psi is shown in Fig. 3. Pressures of this magnitude would be valuable for the testing of plant equipment or for autofrettage of heavy cylinders. Any desired pressure can be maintained by adjusting the intensity of cooling.

To compensate for excessive dilation of the bore at high pressure, a series of balancing chambers is distributed along the balancing barrel. Each of these chambers, sealed by rubber rings and anti-extrusion washers, is pressurised by the fluid being pumped. Discharge pressures of the order of 100,000 psi could be reached with such a pump.

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RUSSIA

Arc Welding with Melting Electrodes in a Protective Gas Atmosphere

By K. V. LYUBAVSKYI and N. M. NOVOZHILOV. (From *Avtogennoye Delo*, January, 1953, pp. 4-8, 5 illustrations.)

THE application of automatic welding under flux meets with considerable difficulties in a number of operations, such as the welding of curved and short seams, joining of bosses to vessels, filling up of cavities due to casting faults, joints between thin wall sheet, etc. These difficulties are associated with the need for equipping an automatic installation for such operations with complicated copying equipment and flux-retaining devices, and with the inability to carry out visual observation during the welding process.

Arc welding in a protective atmosphere has indisputable advantages in these circumstances. However, welding with a non-melting electrode is a slow process and welding with a melting electrode has so far been successfully accomplished only in an atmosphere of one of the expensive or rare inert gases, argon or helium. For this reason, the search for a process of welding with a melting electrode in the atmosphere of a cheap and common gas is of the greatest interest. Until now, such attempts have not proved successful.

From the metallurgical point of view, welding under inert gas differs in principle from welding under active gas, since the former neither dissolves in the molten metal nor forms compounds with its components. An active gas or the products of its dissociation interact chemically or dissolve in the welded metal. In most cases, this is detrimental to the quality of the joint. Certain multi-atomic gases are inert in relation to one metal and active in relation to another. Thus, nitrogen is active with iron and inert with copper. This latter property has led to the development of copper welding under nitrogen.

The speed of interaction between the active gas and the metal is greater when the electrode, as well as the joint edges, melts. The principal defect caused by welding with a melting electrode under protective gas is porosity of the seam. This porosity is caused by the evolution, at the instant of crystallisation, of either hydrogen or nitrogen or carbon dioxide or a mixture of these gases. It has been found that seams welded in an oxidising atmosphere have a somewhat lower concentration of sulphur than seams welded in inert or reducing atmospheres. This can be explained only by the burning of sulphur during welding.

A special investigation was devoted to experiments to determine the possibilities of welding certain steels in a non-inert protective gas, and to study the processes of interaction between active gas and welded metal. In these experiments, thin electrode wire of 2 mm in diameter was automatically fed into the arc region and supplied with a current of 300 A. The welding arc was struck between the parent metal and the electrode in a stream of protective gas which surrounded the melting electrode concentrically. Three different steels were investigated in an atmosphere of carbon dioxide and its mixtures with other gases. The carbon dioxide used in these tests was taken from commercially available cylinders used for soda-fountains. The welded samples were tested in a tensile machine and in an impact testing machine.

The three steels used in these experiments were a low carbon steel, a medium carbon low alloy steel, and stainless steel, respectively. In all cases, suitable compositions of electrode wire had to be found.

The conclusions derived from this investigation are on the whole favourable and the prospects of arc welding under active gas appear to be good, when all components in the process are suitably chosen. It is affirmed that, by welding with a melting electrode under carbon dioxide gas and its mixtures with other gases, sound, dense, and strong joints can be obtained with low carbon, low alloy, and high alloy steels, provided the electrode wire is of the correct composition.

An increase in the coefficients of absorption of various components and elements by the welding bath in welding in an atmosphere of carbon dioxide can be achieved by admixtures of either inert or reducing gases, with a minimum content of hydrogen and nitrogen, both of which cause porosity in the seam.

Welding with a melting electrode in a carbon dioxide atmosphere has been accomplished with a fusion coefficient of 10 to 12 grams/Ah, and a gas consumption costing less than the consumption of flux in submerged automatic welding. Welding under gas offers much greater convenience and adaptability than submerged arc welding.

Electro-Luminescence as a Source of Light

By G. DESTRIAU. (From *Bulletin de la Société Française des Electriciens*, 7th Series, Vol. 3, No. 30, June, 1953, pp. 381-387, 10 illustrations.)

The first surface-radiating electro-luminescent condenser was produced in 1937. *The transparent electrode at that time consisted of a sheet of mica with a conductive outer surface. Further research work was carried out during the war in collaboration with a number of scientists. However, it was only after the author had published in* 1947 *a detailed survey in the Philosophical Magazine that this subject has been considered with increasing interest, particularly in the United States.*

To produce a light source of the electro-luminescent condenser type, a sensitive substance is incorporated in a solid or liquid dielectric situated between two electrodes, as shown in Fig. 1. One of these electrodes is a sheet of transparent glass, with a conductive surface obtained by suitable heat treatment, for instance with mixtures of vapours of tin and antimony chlorides. The other electrode is a metallic deposit obtained by aluminium powder spraying or by thermal evaporation. This coating, in case of breakdown due to excessive voltage, has the advantage of changing into insulating aluminium oxide, which immediately covers the break.

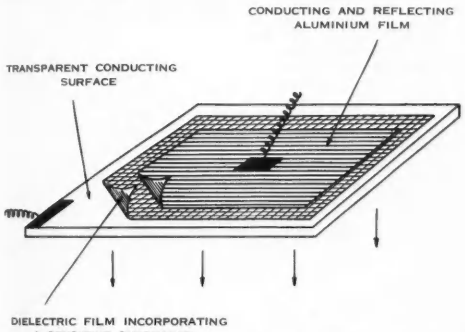
CONDUCTING AND REFLECTING ALUMINIUM FILM
TRANSPARENT CONDUCTING SURFACE
DIELECTRIC FILM INCORPORATING A SENSITIVE SUBSTANCE

Fig. 1. **Schematic diagram of an electro-luminescent condenser.**

To obtain high field strengths without applying high voltages, it is necessary to use extremely thin layers of dielectric, of the order of 0·03 to 0·04 mm. Thicker layers would be of no advantage, since emission is a function of the field intensity and the increase in brightness achieved by superimposing several sensitive layers is not sufficient to compensate losses due to reduced field strength. Luminescence occurs only with variable fields. A constant voltage applied across the electrodes produces merely a rapidly decaying flash during charge or discharge of the condenser. However, the illumination persists over a longer period if the charge or discharge develops gradually.

The sensitive substances incorporated in the dielectric include zinc or cadmium sulphides, zinc oxides and silicates, as well as sulpho-selenides of zinc, subjected to appropriate treatment. Most commercially available substances with fluorescent or phosphorescent properties are not (or are to a slight extent only) electro-luminescent and, conversely, many electro-luminescent substances are not particularly photo-luminescent. Difficulties in procuring suitable substances and in making the thin layers of sensitised dielectric, explain the initial setbacks of some experimenters. More recently, Bernanose succeeded in obtaining electro-luminescence with certain anilines incorporated in thin sheets of cellophane placed in the dielectric.

Electro-luminescence as a Primary Phenomenon.

Some doubts regarding the primary character of the excitation have recently been expressed by Herwelly. He attributes this effect to a secondary excitation of fluorescence by ultra-violet light, produced by discharges which would occur in minute bubbles of residual air. However, this question had been discussed previously and considered untenable. Moreover, Herwelly apparently did not operate under conditions which which could be regarded as appropriate for observing this phenomenon without disturbance from other effects, since he used high voltages with r.m.s. values of up to 12,000 V. However, it was decided by the author to carry out further experiments which would serve definitely to invalidate Herwelly's assumption. It was found that the very thin layers currently used give a clear luminescence at voltages below 100 V (the visibility threshold being situated at about 20 V). With these low voltages, even in the presence of gas, discharges cannot occur. Furthermore, the presence of a large air bubble invariably corresponds to a dark area in the luminous field of the condenser, as a result of the weaker electric field at this position, this weaker field being due to the low dielectric constant of air. In addition, the following experiment was carried out :—Two plane condensers were made, with their electrodes designed in the form of concentric rings. One condenser was used with air in order to obtain discharges, and the other was provided with a solid dielectric. A sinusoidal voltage of the order of 500 V was applied and the light emissions were photographed through a rotating disc provided with a slot and driven by a motor synchronised to rotate at a speed equal to half the voltage-variation frequency. The photographs clearly showed that there is only a slight forward phase shift with electro-luminescence, whereas in the discharges with air, the periods of extinction and illumination show practically a 90 degree dephasing.

The absence of any discharges in the excitation was confirmed by a spectrographic study. For the same substance, comparisons were made of (a) the spectrum emitted by a condenser with air as a dielectric and subjected to a sufficiently high voltage to produce discharges and (b) the spectrum emitted by an electro-luminescent condenser with a solid dielectric. Although the latter spectrum was obtained with a longer exposure, there was no trace of a line due to spark discharge. It should also be mentioned in this connection that a study of the excitation under high-vacuum conditions has been carried out by Thorington, under conditions which made the generation of discharges impossible.

Relations between Brightness, Field Strength, and Frequency.

The light emitted by an electro-luminescent condenser is a function of electric field strength and frequency. The general relation between brightness and applied voltage (at constant frequency) is of the form

$$B = a\,V^n \exp(-b/V)$$

where B = brightness, V = r.m.s. voltage, and a, b and c are constants. As an average value, $n = 2$. This equation, evolved from experiments, has been verified for a number of substances and applies over considerable ranges, i.e., 1 to 10 for voltages, and 1 to 50,000 for brightness. Practically straight lines are obtained by plotting $\log B - 2 \log V$ against $1/V$. In fact, the curves of $\log B$ against $1/V$ are already fairly straight. For smaller ranges of variation, simpler formulae such as

$B = kV^n$ (proposed by Bramley) can be employed. As brightness is largely dependent on the applied voltage, it is necessary to operate as close as possible to the breakdown voltage of the insulator, using small step-up transformers for this purpose.

Brightness can also be increased by operating at a higher frequency. However, the relative rate of the increase varies according to the substance, and the slope dB/df (f = frequency) may be greater or smaller than unity. In some cases dB/df decreases almost to zero after B reaches a certain limit. These differences in behaviour are found both in mineral and organic substances.

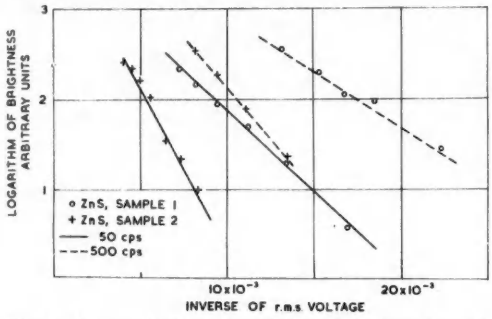

Fig. 2. **Curves showing the variation of the logarithm of brightness as a function of the inverse of voltage, for two different samples of ZnS, at frequencies of 50 and 500 cps.**

Typical results are shown in Fig. 2. At low voltages, the brightness is increased 20 times by increasing the frequency from 50 to 500 cps. At higher voltages, the corresponding increase is only 8 to 1.

It should be noted that in the case of cells incorporating several types of sensitive substances, there is one spectral band for each active substance and each band is excited independently.

Changes in Emission Spectrum due to Field Strength and Frequency.

In substances with several activators, such as, for instance, zinc sulphide with traces of copper and lead (Waymouth), the blue band predominates at low voltages, but at higher applied voltages the green band of lead reaches a greater intensity, so that the colour changes from blue to green. Similar results are obtained by raising the frequency.

Some substances with a single activator show appreciable changes in their spectral bands, but this does not seem to be a general phenomenon. In experiments carried out by Loudette and the author, it was found that mixtures of zinc and cadmium sulphide activated with copper show, under electro-luminescent conditions, a spectral band which is slightly different from the phosphorescence band. Thorington also found spectral changes due to field strength alterations.

Effect of Temperature.

This has been under study since 1938, when it was noted that the threshold voltage of light emission of a zinc sulphide specimen was reduced to half its initial value by raising the temperature from 25 to 110° C. The brightness was increased in the ratio of 3 to 1 when passing from 25 to 120° C at a constant field strength.

The brightness/temperature curve varies according to the substance considered. In many cases, brightness increases with temperature up to a maximum value and decreases thereafter at still higher temperatures. Sometimes the effect is non-reversible ; in other words, if the cell is heated to an excessive temperature, it may not resume its original brightness after cooling down, probably owing to a reaction between the dielectric and the sensitive substance (Waymouth, Jerome and Gungle). Temperature effects are currently being investigated by Mattler over wider ranges.

Waveforms of the Brightness Variation.

The emission of light is not constant but follows the voltage fluctuations with a frequency equal to twice that of the applied voltage. There is no complete extinction between successive peaks and at 50 cps, for instance, the minimum brightness is about one third of the peak value. The electro-luminescence ceases as soon as the applied voltage is cut off, even with substances giving persisting phosphorescent effect after excitation by ultra-violet rays.

The waveform of the brightness curve as a function of time varies for different substances. In some cases there is an additional peak on the flank, either on the upward or the downward slope of the brightness variation curve. In experiments carried out by Mattler and the author, it was found that these secondary peaks occur with mixtures having a high oxide or sulphur content. Moreover, the phase of the brightness curve is slightly ahead of the voltage variation, owing to the low conductivity of crystals. However, single crystals of zinc sulphide, tested by Piper and Williams, show brightness in phase with the voltage variation.

Response to applied voltage is practically instantaneous, and in a few hundredths of a second the peaks of the brightness curve reach about two-thirds of their steady-state value. Brightness increases fairly rapidly during the next 5 to 10 seconds and the increase then continues at a slower rate for a few minutes.

Under steady operating conditions over a period of several thousand hours, the emission decreases by about 30 per cent during the first 1500 hours. After this, it is fairly stable and remains practically constant for several thousand hours. The structural characteristics of the insulator appear to have a considerable effect on the ageing of the condenser. Soft dielectrics age more rapidly and to a greater degree than hard, solid materials. The ageing effect is attributed by Waymouth, Jerome and Gungle to a gradual agglomeration of particles, owing to electrostatic action on the induced dipoles. Solid dielectrics oppose these displacements to a greater extent than soft dielectrics.

Theory of Electro-Luminescence of Solids.

Various American investigators have sought an interpretation of the phenomenon of electro-luminescence of solids in the recombination of electrons and positive interspaces when current flows through a rectifying barrier layer, the simplest assumption being an n—p type barrier. A semi-conductor contains p-regions and n-regions, separated by high-impedance regions, and the emission of light under the action of an electric field appears possible with this explanation. However, in the opinion of the author and of D. Curie, the luminous emission is due rather to an excitation of the light-generating centres by impacts of accelerated electrons in the high-conductivity band. This explanation is closer to the theories related to dielectric breakdown.

Efficiency.

Although, at first sight, it might seem that electro-luminescence gives a direct conversion of electrical energy into luminous energy, the efficiencies obtained are still not very high. Losses occur through absorption of light in the material and the conductive glass. This latter loss is about 20 per cent for a glass 3 mm thick, the absorption being mainly in the conductive film. Furthermore, 50 per cent of the light is emitted towards the rear in the direction of the metal electrode, and only a fraction of this is reflected and transmitted through the dielectric. Thus, 50 per cent efficiency is the maximum that can be expected for electro-luminescent condensers and, in practice, this figure has not even nearly been reached. According to Gluntz, the highest value obtainable is about 6-8 lumen/watt for films incorporating

tellurium ; this seems a very low value compared with the 60 lumen/watt now obtained with fluorescent tubes. Brightness values of 50 ft-lambert can be reached, so that electro-luminescent condensers may be considered as constituting extended sources of low light intensity (surface lighting).

FURTHER DEVELOPMENTS AND POSSIBILITIES.

It would be premature to consider the widespread use of surface lighting by means of electro-luminescent condenser panels, although some installations have already been tried out, particularly at the Waldorf Astoria Hotel, in New York. Apart from some small-scale domestic applications, only certain special arrangements can at present be solved in a satisfactory manner. However, the results show prospects of improvement and the process has been found sufficiently interesting by certain industrial laboratories outside France to justify appreciable financial outlay, in order to secure favourable positions in this new field.

Electro-luminescent lighting with large non-glare surfaces of moderate brightness is practically shadowless and may be said to solve in a " direct " manner the problem of indirect lighting. The dephasing of the current ahead of the voltage improves the power factor and the stroboscopic effect is less pronounced than with fluorescent tubes. Finally, electro-luminescent panels have a very long life and are less fragile than ordinary tubes and bulbs. Furthermore, each piece of a broken condenser can be used as a new source of light. However, a considerable amount of development work is still required before this new light source, which has already passed the stage of pure scientific research, is finally available for practical use.

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GERMANY

Unbalance Tolerances for Rotating Parts

By K. FEDERN. (From *Werkstatt und Betrieb*, Vol. 86, No. 5, May 1953, pp. 243-250, 18 illustrations.)

Increasing demands for smooth running of machines and transport vehicles call for specifications of the accuracy of balancing required. Tabulated data, based on practical experience, help the designer to establish, for each rotating component, the requisite unbalance-tolerances economically practicable.

THE engineer who is normally conversant with balancing techniques may find it difficult to decide, in a given case, which particular method to employ, the rotational speeds to be used, and at what particular point in a production line the balancing process should be inserted. The correct choice of unbalance tolerances is likely to be an even greater problem. Both the workshop and the drawing office lack the experience and the " feel " necessary to judge the appropriate degree of balancing, the main obstacle being the difference between workshop balancing and actual service conditions, coupled with the diversity of form of the rotors. With increasing speeds of rotation and increasing sensitivity to vibration, the distinction between justified and unjustified demands for accuracy of balancing becomes more important. A reduction in unbalance tolerance will obviously increase the time spent on balancing, with a corresponding effect on costs.

The machine-tool industry is also becoming increasingly aware of the importance of balancing as a factor in the achievement of higher speeds and greater machining accuracy. As the harmful effects of unbalance on machine-tools are noticeable at quite small vibration amplitudes, a concrete measure of the accuracy of balance and numerical data on tolerances are important to the manufacturer.

DEFINITIONS OF THE DEGREE OF ACCURACY OF BALANCING

At first sight, a suitable criterion of the quality of balancing would be the running smoothness of the aggregate ; however, many other factors contribute to uneven running (e.g., bearing faults, incorrect alignment, shaft-deflection, aero or hydrodynamic forces, magnetic or thermal effects, etc.), and, in any case, there is no simple relation between the unbalance of the rotor and the vibration amplitudes of the housing, which are influenced by the mass of the housing and foundations, the rigidity of the bearings, proximity to the resonant frequency, etc.

Measurement of the vibration amplitude thus will not indicate directly the degree of unbalance, or whether the running smoothness can be improved by better balancing or by an alteration of the resonant frequency of the aggregate. Nevertheless, for certain classes of machines, such as turbines and generators, valuable practical data exist, which can be used as a guide to the smooth running requirements of such installations, as shown in Fig. 1. Fig. 2 gives similar curves for electric motors, based on practical experience.

The absolute magnitude of the mass unbalance may be expressed as a residual unbalance moment in mm-grams, or as the moment of momentum in mm²-grams. However, the most suitable indication of unbalance tolerances in drawings is by means of the permissible residual unbalance moments referred to two balancing-planes through the body. As an example, consider a crankshaft at 4500 rpm and 25 kg weight ; a static unbalance moment of 250 mm-gr, both left and right, is permissible. Through suitable design, the crankshaft is adapted for balancing on an automatic balancing machine.

The magnitude of the permissible unbalance depends chiefly on the weight of the rotor. Under similar conditions, a larger rotor may be permitted a larger unbalance. For purposes of comparison, the introduction of the concept of *specific unbalance* ϵ (ratio of unbalance moment to weight) suggests itself. Its dimension is linear, and, as it is in fact identical with the displacement of the centre of gravity, this term is often applied to it. This concept, though essentially a static

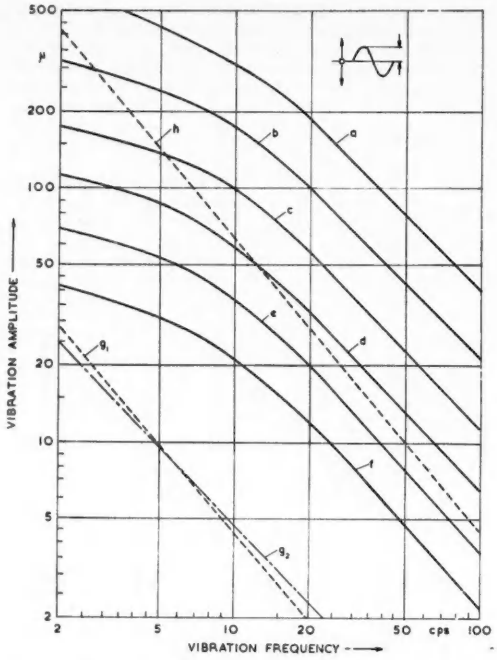

Fig. 1. **Curves for the estimation of running smoothness of large machines with special foundations (after T. C. Rathbone).**

The curves indicate limits for vertical vibrations; for horizontal vibrations of turbines and generators resting on foundations of low resonance, the limits may be increased by 100 per cent. *a* = very rough, immediate balancing necessary; *b* = rough, balancing required; *c* = fairly rough, balancing advisable; *d* = acceptable; *e* = good; *f* = very good; g_1, g_2 = sensory perception levels (g_1 after T. C. Rathbone, g_2 after E. Reiher and F. J. Meister); and *h* = safety limit for buildings.

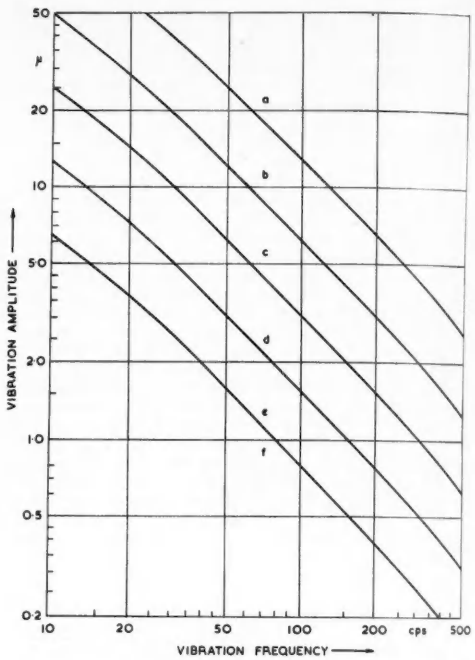

Fig. 2. **Curves for the estimation of running smoothness of commercial electric motors.**

a to *f* as for Fig. 1.

one, may be employed in dynamic balancing problems, provided the concomitant displacement of the axis of inertia is borne in mind.

A rotor running above the resonant frequency of its bearings (elastically suspended) revolves about the axis of inertia or free axis. Its vibrational amplitude is then of the same order of magnitude as the displacement of its centre of gravity. Thus, the " specific unbalance " also becomes significant from the point of view of measuring technique. For a rotor running below the resonant frequency of the bearing (rigidly supported), ϵ still gives a useful picture of the state of balance, and in effect is the ratio of the dynamic to the static bearing load.

Dependence of Unbalance Tolerance on Running Speed.

Measuring and balancing times quickly mount up when unbalance tolerances are reduced. With modern machines, indicating the magnitude and angular position of unbalance, an experienced balancer can reduce the unbalance to 10 per cent of its former value in a single step. An extra operation will be necessary only if the unbalance tolerance is less than 10 per cent of the original unbalance. Automatic balancing machines of the type shown in Fig. 3 are capable of reducing a given unbalance to 5 per cent. In the planning of production lines it is therefore important that unbalance tolerances should, if possible, be so chosen that they can be reached in a " single step " on the balancing machine.

The degree of balancing required depends, apart from the weight of the rotor, on the running speed, the application, the relative masses of the rotating and stationary parts, and the rigidity of the rotor and its bearings. In rationalised production, the decision as to the amount of unbalance permissible must be taken at the design stage, and if the guidance of past experience is lacking, the relevant data must be obtained from experiment. In such experiments, a carefully balanced rotor is provided with increasing unbalance weights and, under operating conditions, the maximum permissible unbalance is determined. Table I gives the magnitude of the usual tolerances for various classes of machine. Clearly, only tolerance *ranges* can be given, but for normal conditions a value at the middle of each range should be adequate.

For instance, the tolerance for a 6-cylinder crankshaft of 35 kg weight (group D) is about 10 mm-gr/kg,

Table I. Unbalance Tolerances.

Group	Type of rotor	Permissible static unbalance in mm-gr per kg weight
A	High-speed gyroscopes, armatures, spindles and wheels of precision grinding machines	0·2-1·0
B	Armatures of small high-speed motors, small and medium size gas turbines, high-speed turbo-chargers, grinding machine drives	0·5-2·5
C	Armatures of small motors, turbo-chargers, turbines, turbo-generators	2-10
D	Armatures of commercial electric motors, fans, machine and machine tool components, fast running transmission components, crankshafts of engines, of 4 or more cylinders, high-speed parts in general	5-25
E	Cardan shafts, 1, 2 and 3 cylinder crankshafts (with unbalanceable reciprocating parts), motor car wheels, rims, etc., low-speed parts of textile machine, agricultural machines, etc.	20-100

Fig. 3. **Automatic balancing machine, accuracy 120 mm-gr.**

i.e., 350 mm-gr in each equalising plane. This agrees with American practice, which employs a tolerance of $\frac{1}{4}$ in-oz for such a crankshaft.

From Table I and Figs. 1 and 2, it is possible to discover the tendency for the permissible specific unbalance to decrease with increasing running speeds, so that approximately $\epsilon_{perm} \simeq \text{const} \times 1/n$, where $n =$ rpm. This tendency agrees with the mechanical principle that for two geometrically similar bodies of different masses, the centrifugal force on the bearings is the same if the product $\epsilon \times n$ is the same for both.

As another example, the armature of an electric hand drill, revolving at 3000 rpm, with a residual unbalance of $\epsilon = 5\mu$, gives the same impression of smooth running as a similar machine running at 15000 rpm with a residual unbalance of 1μ. In such parallel cases, the life expectancy of the bearings would be the same.

If, after balancing a rotor according to the tolerances given in Table I, it still does not run with sufficient smoothness, it would be mistaken policy to attempt to balance it to finer tolerances; the causes of vibration rather should be closely investigated. In this connection, some often overlooked causes are:

(1) After balancing the rotor, a sleeve may be mounted, which, though itself balanced, is distorted by keying and hence causes unbalance.

(2) The rotor has been balanced, but subsequently operates in ball-bearings which may cause a displacement of the centre of gravity.

(3) The rotor, designed to run in plain bearings, is supported in the balancing machine at points other than its intended bearing surfaces.

(4) During balancing, a drive coupling is used, which is itself unbalanced, or which causes unbalance by reason of excessive play or uneven screw-tension.

(5) An armature with loose windings is balanced at low running speeds; high operational speeds may cause a displacement of the windings.

Often also, the reason for lack of success in balancing is insufficient rigidity of the rotor or housing; in such cases, the best remedy is a change in construction, to move resonant frequencies outside the range of operational speeds.

With disc-shaped rotors, the mistake of balancing in one plane only was often made in the past, but it is now recognised that the only satisfactory solution in this case also is dynamic balancing in two planes.

Rotors with Special Balancing Requirements.

Rotors of Group B must be balanced with their ball-bearings mounted, as their unbalance tolerance is smaller than that of the bearings themselves. If temporary dismantling is necessary after balancing, the relative angular positions of bearing race and shaft must be marked. Modern balancing machines can cope with the problem of supporting all types of ball and roller bearings without difficulty.

Keeping to the tolerances of Group A is justified only if the rotors are balanced in their housings after final assembly. Any subsequent interference with the bearings, even a slight axial adjustment, will normally bring about centre of gravity displacements up to 2μ. In balancing rotors of this group, the best plan is to allow them to be driven by their actual driving mechanism, or by compressed air. The angular position of the unbalance mass is measured by stroboscopic means or, more accurately, by photo-electric locating apparatus coupled with an oscillograph or wattmeter. Fig. 4 shows a photo-electric unbalance locator operating on a precision balancer employed in the mass production of vacuum-cleaner impeller assemblies.

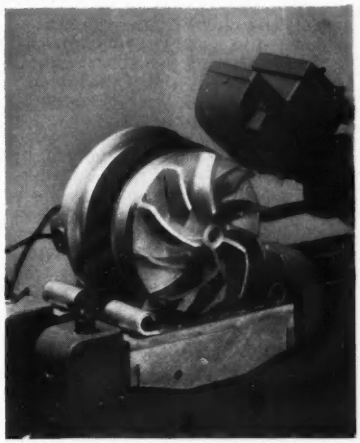

Fig. 4. **Precision balancing of a vacuum-cleaner impeller assembly on an electrodynamic balancing machine with photo-electric phase indicator.**

Balancing rotor parts on auxiliary spindles or mounted on auxiliary flanges will give satisfactory results only if, apart from the unbalance of the auxiliary shaft, the centricity of the motion and the play between the fitting surfaces are strictly controlled. The sum of the eccentricities must, of course, lie below the tolerance limit; otherwise, the accuracy obtained will be fictitious. Conical seatings have the decided advantage of excluding undesirable play.

When balancing, on a production basis, parts to be mounted together, it is advantageous to mark the position of the static unbalance on the various parts by a coloured spot. This enables the superposition of unbalances to be avoided at the assembly stage. The method may be applied to the balancing of tyres, where the most advantageous position of the valve may be similarly marked.

The best method of balancing parts centered against each other is to balance the outer part (e.g., flywheel) separately on an auxiliary shaft, and then to balance the assembled unit as a whole. The unbalance due to the eccentricity of mounting surfaces is then automatically eliminated. Errors caused by large fit tolerances can be minimised in production runs by placing the separately balanced parts in the same angular position on the auxiliary shaft. On mounting, all these parts will

then have the same position with respect to the gravitational field.

Rotors with keyways are normally balanced together with dummy keys, arranged to fit flush with the shaft. In production, the insertion, each time, of such a half-key may be eliminated by compensating the driver with a compensating key. If the plane of the keyway and that of the compensating key cannot be made to coincide, the resultant unbalance moment must not be neglected.

When small parts of rotors, as, for instance, impellers for compressors, are separately balanced, it would be uneconomical to balance them to the degree of accuracy given in Table I. It is advisable to add to such parts a reasonable amount, say one third of the weight of the shaft or main rotor, before the unbalance tolerance is calculated. Similar considerations apply to machine tool parts.

TESTING THE ACCURACY OF BALANCE.

(a) *Testing before assembly.* The methods of rolling the rotor on horizontal parallel rails, or marking the rotor, revolving in rubber-mounted bearings, with chalk, are not nowadays considered sufficiently accurate. The so-called "run-out" machines are more suitable for testing, provided they do not require a special drive coupling. In these machines, the vibration amplitude is measured at the free bearing, when passing through resonance, and runs are repeated four times with an artificial unbalance of the order of the tolerance for the given rotor, shifting the artificial unbalance by 90 deg each time. A plot of the results will have a sinusoidal appearance, from which the magnitude of the actual unbalance can easily be found. If a drive coupling has to be used, this complicates the procedure, but its effect can be eliminated by keeping it in the same angular position as the added unbalance. The balancing on a machine with stroboscopic indication must be checked similarly, as the stroboscopic angle indication itself is not usually sensitive enough for checking purposes.

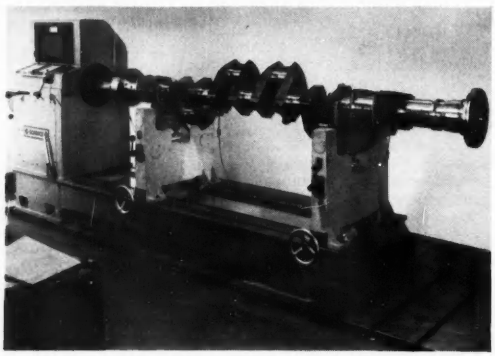

Fig. 5. **Electrodynamic universal balancing machine.** Range 5-1000 kg; 250-2000 rpm; sensitivity = 1 division per 1μ specific unbalance.

The simplest and quickest way of checking is by means of an indicator type machine, which allows the magnitude and position of the unbalance to be read off directly. A modern machine, with a capacity of up to 1000 kg weight, is shown in Fig. 5. The sensitivity of such apparatus is usually much greater than the requirements set out in Table I. Two test runs are performed with the test-piece clamped in positions 180 deg apart with respect to the coupling on the driving shaft. By taking the mean of the two readings, the possible unbalance of the coupling is eliminated.

(b) *Testing after assembly, under operating conditions.* With the assistance of the tests described above, the performance of the balancing machines and the care taken by the operators can be checked. Such tests cannot, however, satisfy the purchaser of the finished product, who wishes to be assured of satisfactory running under actual operating conditions, which cannot in every case be reproduced by the maker, especially at very high running speeds.

For occasional or spot checks, where medium accuracy is required, simple vibration amplitude meters, e.g., mechanical vibration meters with a threshold sensitivity of 5μ, or electric vibrometers with dial indicators (sensitivity 2μ) can be used. The latter, in portable form, is illustrated in Fig. 6. However, such instruments are usually not suitable for the location, as distinct from the detection, of unbalance masses.

Fig. 6. **Vibration measurement on a rotary converter by means of an electric vibrometer.**

If other causes of rough running are to be analysed at the same time, it is advisable to employ an oscillograph in conjunction with the vibrometer, to give a picture of the vibration cycle.

An installation suitable for the production testing of smaller units, such as small or medium electro-motors, consists of a bridge suspended by extension springs, carrying the test piece, and a wattmeter indicating the magnitude and location of the unbalance. The freely suspended bridge avoids the distortion of the vibration amplitude and the displacement of phase, inevitable with rigid supports capable of resonance. This form of test also enables the unbalance vibrations to be separated from other forms of vibration. Many firms now employ such testing apparatus in their motor production, and provide rings drilled with equalising holes for fine correction, these being accessible after assembly.

A balancing rig is often introduced nowadays in the mass production of internal combustion engines, to control the unbalance of the moving parts of each unit. Such checks are intended to show the distribution of the unbalance weight between crankshaft, flywheel, vibration damper, and clutch, and to indicate to what extent the differences in weight of the connecting rods and pistons are responsible, and the effects of the tolerances on fits and eccentricities of the crankshaft assembly. Such investigations are not only important from the point of view of quality control, but give valuable information for improvements in design and manufacture.

Cone Arc Welding

By P. Patriarca and G. M. Slaughter. (From *The Welding Journal*, Vol. 32, No. 7, July, 1953, pp. 597-602, 12 illustrations.)

A new inert-gas-shielded semi-automatic arc-welding process, known as the cone arc process, is described and evaluated by experiment. The process utilises standard welding equipment and is applicable to the fabrication of miniature tube-to-header type heat exchangers. An investigation of the effects of arc current and welding time indicated that these variables were not critical and that precise control of their magnitude was not necessary within liberal limits.

The fabrication of an assembly consisting of a multitude of thin-walled, small-diameter tubes, welded into a single header by conventional welding techniques, has proved to be extremely difficult, if not impossible, to accomplish with consistency and reliability. Initial experiments with an inert-gas-shielded arc-welding process, suggested by previous investigators, showed considerable promise in the welding of small tubes to headers. In this process, now known as the cone arc process, it has been postulated that the arc rotates around the header hole at high speeds, distributing uniformly the energy required to make a peripheral weld of a tube into a header sheet.

This study, undertaken by the Welding Section of the Metallurgy Division of Oak Ridge National Laboratory, Tennessee, was initiated to determine the limitations and the range of application of the cone arc process.

Welding Equipment.

Apparatus suitable for cone arc welding was assembled for the most part from commercially available equipment. A 200 A d.c. welding generator was used as the welding power supply and was supplemented by an adjustable series resistor, which permitted obtaining a stable arc at a current level as low as 5 A.

The high frequency required for reliable starting of the inert arc was provided by a spark-gap oscillator and was used in conjunction with thoriated tungsten electrodes. The commercially available timing circuit used to time the duration of arc current was found to be reproducible within 0·05 sec with arc times of 0·5 sec or over.

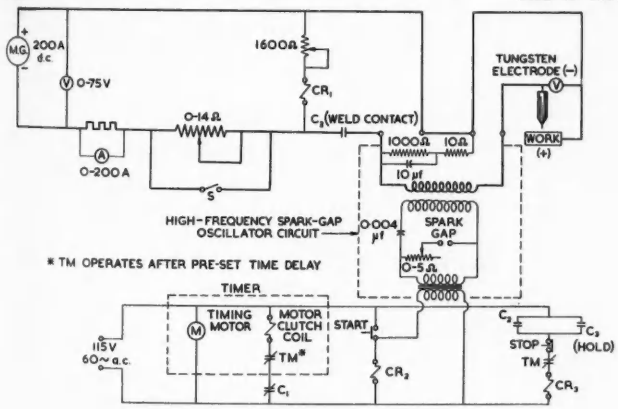

Fig. 1. **Cone arc welding circuit diagram.**

A welding contactor was incorporated into a control circuit, the operation of which, with reference to the schematic diagram of the circuit, shown in Fig. 1, was as follows :

Upon starting the welding generator, the open-circuit voltage of from 50 to 70 V energises relay CR_1 and operates contact C_1, permitting the timer circuit to reset. When the welding operator momentarily depresses the start button, weld contact C_3 closes, and the high-frequency oscillator is energised to assist in starting the welding arc. At the instant that the open-circuit voltage drops to arc voltage, the contact C_1 or relay CR_1 opens, allowing the timer to begin timing. At the end of the preset timing period, the contact TM opens, thereby de-energising relay CR_3 thus opening the weld contactor C_3 and breaking the cone arc welding arc. This arrangement enables accurate control of arc current duration, independent of any relay in the arc striking by the high frequency pilot.

A commercially available machine holder, provided with an Alnico permanent magnet nozzle, was used as the welding torch and may be considered as the fundamental requirement for the cone arc process. The portion of the nozzle directly above the stainless steel tube and header work is of soft iron and serves to concentrate lines of flux roughly parallel to the axis of the welding electrode. The Alnico permanent magnet is directly above the soft iron, the remainder of the nozzle being of aluminium and plastic.

It has been proposed that the operation of a cone arc is dependent on the establishment of an arc stream which cuts the lines of flux at a small angle. Since the welding arc originates at the cathode spot at the tip of the pointed thoriated tungsten electrode centered above the tube, and must impinge on a point on the periphery of the header hole to complete the welding circuit, this requirement is realized.

The arc current under these conditions cuts lines of force in the magnetic field, and it has been postulated that a force, tangential to the tube periphery, results, active in the plane of the header sheet. These forces are said to result in the rotation of the initial arc beam around the header hole at very high speeds, thereby distributing the energy required to make a uniform peripheral weld of a tube into a header sheet.

Instrumentation.

Instrumentation found satisfactory for reproducible results consisted of means for the measurement of the arc voltage, arc current and the duration of the welding current. A six-channel, film-type recording oscillograph was employed initially for this purpose, since the arc times used in this investigation were generally shorter than the speed of response of indicating type panel instruments. Subsequent experiments indicated that panel meters, calibrated against oscillographic traces to correct for the slow speed of response, could be used satisfactorily to check the duplication of established welding conditions.

Experimental Procedure.

The variables associated with cone arc welding which received attention during this investigation were as follows :

(1) Arc current magnitude, (2) arc current duration, (3) arc length, (4) inert-gas shield, (5) work geometry (header and tubing configuration).

It was recognised that the uniformity of heat transfer during welding was a very important variable. Since the header geometry, header size, and tubing size

would affect the behaviour of the heat flow pattern away from the weld pool and hence the uniformity of the finished weld, experiments were conducted using a single tube-to-header geometry.

Circular headers, 1·10 in. in diameter were fabricated from type 316* stainless steel sheet, 0·125 in. thick. Nineteen 0·100 in. diameter holes were drilled to receive type 316 stainless steel tubes, 0·100 in. O.D., 0·010 in. wall and 3 in. long. The basic header pattern was an equilateral triangle with a header hole drilled at each apex. This geometry resulted in a minimum of 0·100 in. between adjacent tubes, or between a tube wall and the edge of the header.

The effect of arc current magnitude was determined by varying arc current over a range of from 40 to 85 A with an arc time of 1·5 sec and an arc length of 0·050 in. The effect of arc current duration was determined by varying the arc time through a range of from 1 to 5 sec, while maintaining the arc current at 59 A d.c., with an arc distance of 0·050 in.

The effect of arc length was investigated by determining the conditions required for obtaining 19 consistent and uniform welds at each of two arc distances of 0·050 and 0·100 in. respectively, measured as the perpendicular distance from the tip of the tungsten electrode to the plane surface of the header sheet.

The electrode, 0·0625 in. in diameter, was lowered into the 0·080 in. I.D. of each tube, and centered by eye to a reproducible accuracy of $\pm$0·002 in. The chosen arc length was reproduced by referring to a magnified scale mounted on the electrode holder, reading in 0·001 in. increments.

Initial experiments indicated that an argon gas shield provided excellent arc stability during the short welding times required for cone arc welding, whereas, with helium, the arc proved to be somewhat erratic and extremely difficult to start with high frequency at the open-circuit voltages available. Experiments were conducted to determine the argon flow rate required to ensure a clean, bright weld at all times. As a result of these experiments, an argon gas flow of 30 cfh was used throughout this investigation.

Complete header samples, consisting of 19 tube-to-header joints, were welded, with each set of welding conditions considered to be close to optimum, in order to evaluate the consistency of the welds.

Results.

Fig. 2 shows a typical cone arc weld oscillogram illustrating the instantaneous behaviour of arc current and arc voltage as a function of time. Referring to Fig. 2, reading from right to left, it may be seen that the arc current exhibits an initial surge value approximately double the steady-state arc current, and then decays exponentially to the steady-state value in approximately 0·2 sec. The addition of 0·5 ohm of series resistance to the welding circuit effectively eliminated the surge current.

Cone arc welds were made with the modified circuit, in order to compare the results with those obtained with a surge current present. Metallographic examination of these welds indicated that the presence of a surge current was not deleterious within the limits of this investigation, since no significant differences between welds were evident.

It was established that typical cone arc welds can be described metallographically and dimensionally by three parameters, D_I, D_0 and P, as defined below :

D_I = average minimum diameter of the tube hole after welding, measured with a microscope.

D_0 = average maximum diameter of the weld pool, extending outward from the tube onto the header sheet, measured as above. Both D_I and D_0 could be determined without sectioning, by viewing the weld from above.

P = penetration, taken as the minimum perpendicular distance between the unwelded root of the weld to the surface of the weld. Penetration was measured microscopically after the weld had been prepared for metallographic examination by polishing a section along the diameter of the tube.

* An austenitic stainless steel containing 0·10 per cent max. C, 16·00-18·00 Cr, 10·00-14·00 Ni, 1·75-2·75 Mo.—Editor, E.D.

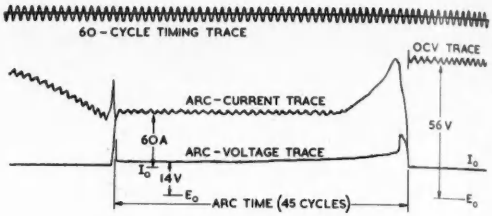

Fig. 2. **Typical cone arc weld oscillogram.**

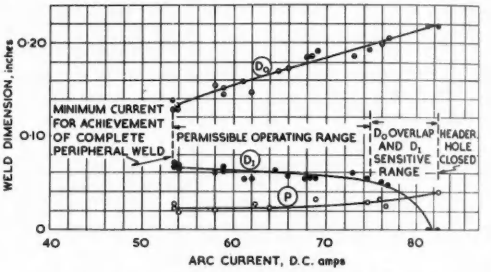

Fig. 3. **Effect of time on parameters D_0, D_I and P.**

The effect of arc current is shown in Fig. 3. D_0, D_I and P are plotted as a function of arc current magnitude with the other welding variables held constant, as follows :

Material: Tubes, type 316 SS—0·10 in. O.D., 0·010 in. wall.
Header, type 316 SS—0·125 in. thick.
Tube hole separation—0·10 in. (one tube diameter).

Welding Conditions :
Arc time—1·5 sec.
Arc distance—0·05 in.
Thoriated tungsten—0·0625 in. (pointed).
Argon gas flow—30 cfh.

Examination of these curves will reveal that about 53·5 A were required before a complete peripheral weld was achieved.

Visual observation during the production of cone arc welds revealed the initial formation of a small crescent-shaped weld pool at any random point on the header periphery, which very rapidly grew circumferentially into a continuous pool, unless the current was too low, or the time too short.

These observations also resulted in the choice of the name " cone arc " for the process. To the observer, the arc appeared as a conventional inert-gas-shielded arc, in that an intense cathode spot appeared at the tip of the electrode, surrounded by a less intense cone-shaped halo, the base of which conformed to the header hole periphery. Experiments using high-speed photography are planned as part of the future work to aid in the determination of the exact nature of the cone arc.

The predominant effect of increasing arc current over the permissible operating range indicated in Fig. 3 was to increase the value of D_0, with a relatively minor decrease in D_I and a slight increase in P. At the higher current levels, the range referred to as " D_I sensitive and D_0 overlap " appeared, both of these conditions

being objectionable. In addition to the probability of closing the header hole at higher current levels, D_0 became large enough to overlap the adjacent weld, thereby introducing a possible non-uniform heat sink for the succeeding weld. The introduction of distortion, increasing with increasing current, suggested an optimum current level in the order of 55 to 60 A at the other conditions described in the graph of Fig. 3. In general, however, it was concluded that the current magnitude was not a critical variable since satisfactory cone arc welds were obtained over a relatively wide range of currents.

The effect of arc time on the parameters D_0, D_1 and P was determined in a similar manner. The results reveal behaviours comparable with those exhibited by the curves of Fig. 3. The predominant effect was once again an increase in D_0, with a relatively minor decrease in D_1, and a slight increase in P with increased arc time. A minimum time at a given current for a complete weld, a D_0 overlap, and a D_1 sensitive range were evident. Since distortion increased with increasing arc time, the curves obtained suggested an optimum current duration of from 1·5 to 2 sec, although a relatively wide range of arc times was permissible for satisfactory results.

CONCLUSIONS.

(1) The cone arc welding method was found applicable to tube-to-header heat exchanger assemblies involving small diameter thin-walled tubing and headers of the size and material which were used in this investigation and which probably cannot be effectively welded by conventional techniques.

(2) Cone arc welding equipment may be assembled from commercially available and relatively inexpensive components.

(3) The major variables, arc current and arc time, were not critical within reasonable limits, indicating that precision control of these variables was not required.

(4) A hole-to-hole distance, measured between centres, of approximately twice the outside diameter of the tubes was found desirable to avoid overlapping of the fusion zones.

(5) By proper selection of welding variables, penetrations of the order of two to three times the thickness of the tube wall could be obtained without objectionable reduction of the inside diameter of the tube. Greater penetration could be obtained only at the expense of a reduction in the inside diameter of the tube, by the constriction of the extra volume of fused metal.

GERMANY

Cathodic Protection of Iron and Steel

By H. KLAS. (From *Stahl und Eisen*, Vol. 73, No. 15, July 16, 1953, pp. 971-974, 2 illustrations.)

CORROSION is an electro-chemical process. Inhomogeneities on the metallic surface lead to local " cells," i.e., to the formation of anodes and cathodes. At the anode, electrons are emitted from the metal, and metal goes into solution with the surrounding medium ; at the cathode, electrons are absorbed into the metal, and a reduction tends to take place. The electric current formed by the flow of electrons is a condition of continuing corrosion, and the speed of corrosion is proportional to the amount of current flowing. Corrosion stops if the current is compensated by superposition of an external circuit of opposite potential or by the mere introduction of an external anode, consisting of a baser metal than the surface to be protected, e.g., of zinc or magnesium. Both methods render the whole metal surface cathodic and are therefore commonly called *cathodic protection methods*.

The corrosion current is determined by the initial open-circuit potential between anode and cathode, but changes during the course of corrosion in such a way that the potential of the cathode appears to be lowered to that of the anode. It is therefore a valid criterion for complete cathodic protection that the open-circuit potential of the cathode should drop entirely to that of the anode. However, not only the magnitude, but also the distribution of the corrosion currents, must be considered in cathodic protection.

The efficiency of the protection depends on the required density of the superimposed current and on the counter-potential producing this current. Approximate values of some protective current densities are given in Table I ; they will obviously vary widely according to the chemical properties of the surrounding medium.

TABLE I. CURRENT DENSITY FOR THE CATHODIC PROTECTION OF STEEL IN VARIOUS SURROUNDINGS[1].

Surrounding medium	Required current density A/cm² of steel surface
Anaerobic soil, sulphate reducing	45×10^{-6}
Seawater in movement	15×10^{-6}
Fresh water in movement	6×10^{-6}
Aerated neutral soil	$3{\cdot}5 \times 10^{-6}$

The counter-potential for the protection of iron in various electrolytes is between —0·272 and —0·291 V. Since it is measured with the aid of a reference copper/copper sulphate electrode, a potential of —0·54 V between steel and this electrode must be added. With a small safety margin, the required counter-potential is thus —0·85 V. In order to check whether this protective potential has been obtained, the part to be protected is fed with current via an auxiliary anode and the voltage drop is measured between various points on the surface to be protected and the surrounding medium. If the entire surface shows a potential of —0·8 to —0·85 V, measured against the $Cu/Cu\,SO_4$ reference electrode, then the part will be completely protected. If the potential drop is less, the anode current or distance must be changed or several anodes suitably arranged. With pipe lines, the point at which the potential just drops below the required value can be found, and the voltage drop along a suitable length of the pipe measured. The anode current needed for this length can then be calculated from the voltage drop divided by the resistance of this length of pipe. It will be seen that the potential difference between anode and cathode, the state of the surface to be protected, and, above all, the conductivity of the surrounding medium, influence the anode current. Since these values are rarely known accurately, it is not always possible to dispense with experimental determination, although experience may yield a fairly reliable preliminary estimate for design purposes.

The number, arrangement, and distance of the anodes from the surface to be protected and from each other depend on the capacity of the anodes in ampere-hours, on the size and state of the surface to be protected, and on the resistivity of the soil. If an external circuit, with rectifiers or generators, is used (Fig. 1 right), the anodes usually consist of iron or steel scrap or graphite bodies mounted vertically or horizontally in pits filled with powdered coke, so as to reduce the soil resistance near the anodes. As the total circuit resistance is more or less fixed, the capacity of the arrangement depends on the voltage that can be applied. This voltage is limited

by the danger of stray currents and by its unfavourable influence on the protective coating. A steel pipe with bituminous paint should not show a higher potential than —1·0 to —1·1 V with respect to earth, measured with the Cu/Cu SO_4 electrode. Foreign or stray currents may lead to higher potentials so that the pipe line may have to be " drained " electrically before installation of cathodic protection. Shape and size of the anodes are determined by the fact that the total current output increases with increasing anode surface, while current density per unit surface area decreases logarithmically. However, the corrosive wear and change of the anode surface, to ensure long life with a fairly constant current capacity, must also be considered. The corrosive losses are 15 to 20 lb per ampere-year for steel anodes (pipes); 2 to 20 lb per amp-year for cast iron; and about 2 lb per amp-year for graphite and carbon anodes. The wide variation in values for cast iron are due to a graphite layer which often forms on the surface of cast iron.

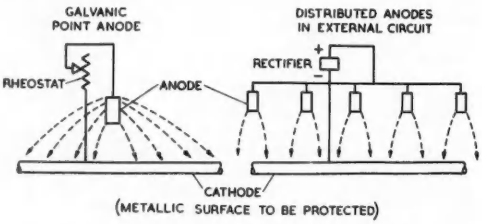

Fig. 1. **Arrangements for cathodic protection.**

If external anodes of a baser metal (galvanic anodes) are used (Fig. 1 left), the resistance of the soil determines the current for a given size of anode. The smaller the resistance, the greater is the current density and the loss in weight. A uniform surface current is obtained by embedding the anodes in suitable materials of high conductivity, such as mixtures of gypsum and clay, with additions of sodium sulphate. If the composition of the soil is unknown, the current output must be measured, to determine the best ratio of the surface to the volume of the anode. The following theoretical formula[2] gives the relevant quantities for this form of cathodic protection:

$$I_c < k\,\Delta E/f_L$$

where I_c is the protective current density (A/cm²), k the specific conductivity of the electrolyte (Mho/cm), and ΔE the potential difference between protected metal and anode. The factor f_L depends on the geometrical shape of both electrodes and is (a) $f_L = A/4\pi r$ for an anodic sphere of radius r connected conductively with the surface area A of the protected metal, or (b) $f_L = A/8r$ or $= A/4r$ for a similarly connected small anodic disc of radius r in contact with the electrolyte on one or both sides. The distance between cathode and anode is of no importance, provided it is large compared with r. The formulae also apply approximately to other shapes of anode, if these shapes are assumed to be reduced to spheres or discs of equal surface area. If the theoretical corrosive loss of the anode is known (see Table II), the most favourable shape can thus be determined for a given life and protective current density. Where the soil resistance is small, and especially where the metal to be protected also has a non-conductive coating, current output may exceed the required protective current. The provision of resistances will then serve to reduce the current and hence the corrosive wear on the anode. In practice, only zinc, magnesium and its alloys, or aluminium and its alloys are used as anode materials.

Table II. Electrochemical Properties of Anode Metals for Cathodic Protection.

Metal	Specific gravity	Standard potential against Fe, V	Current capacity Ah/lb	Theoretical corrosive loss lb/amp–year
Zinc	7·12	—0·33	372	22·95
Magnesium	1·74	—1·13	1000	8·53
Aluminium	2·69	—1·26	1355	6·30

Note: Corrosive loss causes an irregular change in shape of the anode, so that in practice only half the given current capacity is used.

Zinc causes only a small change in potential, and hence supplies only a small current. It is used where the potential drop between metal and electrolyte is less than —0·49 V, as measured against a Cu/Cu SO_4 electrode, and where the resistivity of the electrolyte is below 2000 Ohm-cm. Zinc must be pure, since even small additions of cadmium or lead enhance its surface potential. Magnesium, usually alloyed with 6 per cent Al and 3 per cent Zn causes a larger change in potential, and can be used in electrolytes up to 5000 Ohm-cm resistivity. Aluminium and its magnesium alloys also give large changes in potential but the bedding material must carry suitable additions, to prevent the formation of a passive surface layer.

Fig. 1 shows different arrangements of anode and circuit arrangements. Obviously, point anodes and distributed anodes can be arranged with either circuit. Distributed anodes must not be too near each other, otherwise, they may act as one combined anode with reduced current density. As a rule, their distance must be about 50 times the diameter of circular, long anodes. Variations in anodic and cathodic resistance will change the required protective current. A protective coating may deteriorate with time and the required current then increases. Electrolytes containing calcium- or magnesium bicarbonate will produce protective layers on the surface of the metal, with a consequent decrease in the required current. In seawater and in many brackish waters, a high initial current density of 58 to 380 $\times 10^{-6}$ A/cm² produces a protective layer in a few days, so that the current can then be reduced to 2·3 to 2·7 $\times 10^{-6}$ A/cm². The normal current of about 15 $\times 10^{-6}$ A/cm² for seawater would produce a protective layer only after a long time. Similar protective layers have been observed in ordinary soil; as they reduce the required current and are therefore economically advantageous, repeated measurements of the resistance should be taken.

Cathodic protection is increasingly used in the U.S.A. for pipe lines and for oil-drilling operations under the sea, for the inner and outer protection of tanks, for waterworks, and for cable sheaths, etc. The protection safeguards a plant even under very unfavourable conditions, and can be installed after the plant has been completed. It is true that the capital costs are considerable; however, although these costs can be determined fairly accurately in advance, the economic advantage can only be estimated, as it is impossible to evaluate the costs of maintenance and repair which would have been necessary, had no protection been provided. However, the fact that its application is becoming more and more frequent indicates that cathodic protection is economically sound, provided it is planned by experts on a basis of careful design and extensive measurement. In some cases, its application will be impracticable because the resulting stray fields may damage other parts of the plant, or a correct arrangement of the anodes is impossible. The increasing amount of literature[3] on cathodic protection is indicative of the general interest taken in its development.

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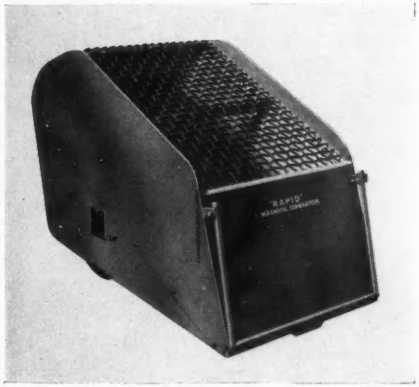
New Materials, Processes and Equipment

In addition to other new items, this issue includes a selection of some interesting exhibits shown at the 6th Canadian International Trade Fair, Toronto (June 1-12), the 3rd European Machine Tool Exhibition, Brussels (September 4-13), and the 14th Society of British Aircraft Constructors Exhibition, Farnborough (September 7-13).

PORTABLE MAGNETIC FOUNDRY SEPARATOR

A new addition to the range of magnetic separators manufactured by Rapid Magnetic Machines Ltd., of Birmingham, is the "Rapid" Portable Foundry Separator, for use in jobbing foundries to extract sprigs, brads, gaggers, risers, and other ferrous content from foundry sand.

The equipment includes a "Rapid" permanent magnet pulley incorporated in a short conveyor, the belt of which is of the rubber and canvas heavy-duty type. The steel screen is of robust construction. The conveyor motor is internally housed and well protected from dust, etc., including the chain drive, which has its own chain guard. The starter is of the push-button type and is readily accessible.



The machine is so balanced as to be easily moved according to site conditions, and the handle is collapsible, to obviate obstruction when the equipment is in use. The entire separator is totally enclosed, and the wheels are specially designed to manoeuvre easily over uneven or soft ground floors.

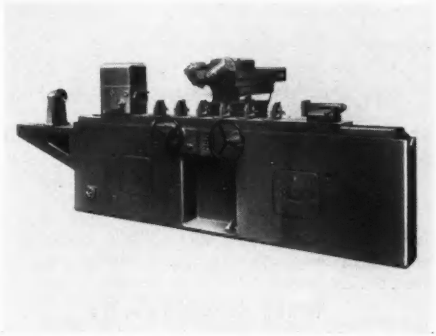
BROACH SHARPENING MACHINE

To be able to serve a wide field of requirements, the "Matrex" No. 54 Broach Sharpening Machine, manufactured by Coventry Gauge & Tool Co. Ltd., of Coventry, is available in three types:—(1) Manually operated, for round broaches only; (2) manually operated, for round and flat broaches; and (3) hydraulically operated, for round and flat broaches. With the exception of the hydraulic feature, all types are of similar design.

The hydraulically operated machine (illustrated) has been specially designed for sharpening all types of circular, flat, and spiral broaches. The cutting efficiency of broaches can therefore be maintained on the spot, obviating the necessity for returning them to the makers for re-sharpening.

No particular skill is required to operate the machine, which is of simple design, while the steady position of the operator, coupled with the handiness of the controls, enables good and even work to be performed.

The machine consists of a substantial base, which carries a work slide, actuated by a large handwheel to the left of the operator. This slide can carry fixtures or a magnet chuck for flat broaches and for round or spiral broaches. A headstock and tailstock, with steadies, are bolted to this slide in any convenient position. A second large hand-wheel, to the right of the operator, actuates the vertical slide controlling the elevation of the wheelhead. This slide is balanced and contains the hydraulic pump of $\frac{1}{3}$ hp at 2800 rpm.



The wheelhead unit can be swivelled in a horizontal plane to accommodate different types of broaches. The grinding-wheel spindle is integral with its motor and can be inclined through any angle, to suit the broach being ground. The wheelhead spindle is clamped to the horizontal wheel slide, the traverse of which is controlled by a conveniently located foot pedal in the base recess. The main wheel spindle is driven by a self-contained motor of 0·8 hp at 2840 rpm.

Rockwell Machine Tool Co. Ltd., of London, N.W.2, are the sole selling agents for this machine.

AUTOMATIC AIR PRESSURISING KIT FOR AIRCRAFT

The automatic maintenance of two separate air pressures in radar and other electronic equipment has become increasingly important in many types of aircraft. The Lear-Romec "Hi-Lo" pressurising kit, model RR-9370, manufactured by Lear Inc., Romec Division, of Elyria, Ohio, is specially designed for pressurising two distinct pressure systems.

The unit has a common inlet through a silica gel dehydrator, admitting dry air only. The air pumps are free from oil, so that compressed air is free from both oil and water vapour.

Through a combination of relay, solenoid valve, and absolute pressure switches, the unit is designed to satisfy high-pressure requirements before air is pumped on the low-pressure side. In addition, each pressurising system has a signal switch for remote electrical warning of undue pressure drops.

In operation, the high-pressure side is compressed to 43-47 psi absolute and then the low pressure side is compressed to 13-17 psi abs. Two oil-free air pumps operate in series to accommodate the relatively high

GOODYEAR BELT GIVES TROUBLE-FREE SERVICE ON INTRICATE DRIVE

Extreme flexibility proved in woodwork factory

FOUNDED as a cooperage in 1878, the firm of Craigs Ltd., Widnes, has steadily expanded ever since. Today it combines a flourishing timber merchanting business with large scale woodwork manufacture for the building, chemical, engineering and textile industries.

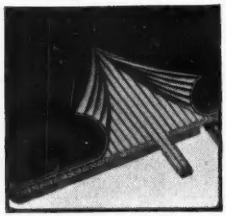
On the manufacturing side, Goodyear transmission belts are giving highly satisfactory performance under the toughest working conditions.

On this sanding machine, for example, a Goodyear Endless Cord Belt is giving outstanding service. Here, the 35 h.p. drive entails six changes of direction, combined with a regular lateral movement of the roller pulleys. Belt speed is over 2,000 feet per minute. Goodyear Endless Cord Belts were adopted after other types of belt had been proved unsuitable for the drive.

WHY GOODYEAR?

Why are Goodyear Industrial Rubber Products so completely reliable? Because they are the result of over 50 years' experience in rubber engineering. Because skilled Goodyear technicians supervise their manufacture at every stage. That is why Goodyear products are giving years of trouble-free service, the world over.

GOODYEAR ENDLESS CORD BELT



A belt with exceptional flexibility that permits greater speed over small pulleys. The load is carried by a central layer of robust, low stretch cords, continuously wound so that joints are eliminated. Balanced construction of the cords and of the tough fabric envelope ensure true running. The Goodyear Endless Cord Belt carries 33⅓ per cent. more load than any other belt of equal thickness.

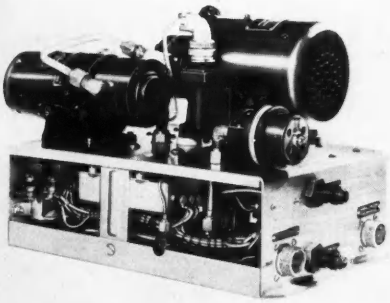
★ **Goodyear Endless Cord Belts successfully tackle a complicated drive with six changes of direction. This is a sanding machine in the woodwork factory of Craigs Ltd., timber merchants at Widnes. Tough, dependable Goodyear belts are used exclusively throughout the plant. (NOTE. The guards have been temporarily removed from this drive to facilitate photography.)** ★

Illustrated and informative catalogues are available for all Goodyear Industrial Rubber Products. Please write to Dept. Y, Goodyear Tyre & Rubber Co. (G.B.) Ltd., Wolverhampton, stating the products in which you are interested.

GOODYEAR

INDUSTRIAL RUBBER PRODUCTS

TRANSMISSION BELTING · V-BELTS · CONVEYOR BELTING · INDUSTRIAL HOSE

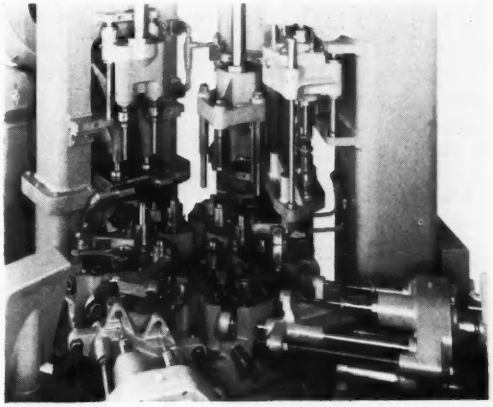


capacities required. For example, the unit is capable of pressurising a one cubic foot vessel to 43-47 psi abs. in 10 minutes or less, under conditions of a 15 cu in./min leakage rate in ambient pressure of 20 in. Hg absolute. Air pumps are $^1/_5$ hp and $^1/_{15}$ hp, 27 V, d.c. Weight of the complete unit is 15 lb.

SIX-SPINDLE SPECIAL PURPOSE MACHINE

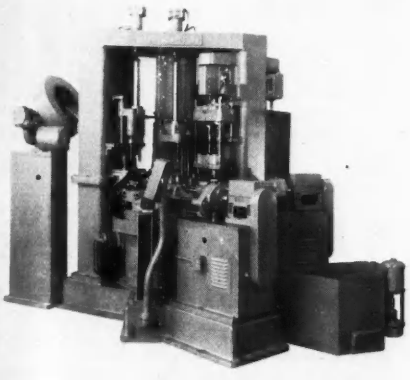
The machine tool exhibits at this year's Sixth Canadian International Trade Fair, Toronto, again formed a substantial proportion of the total exhibits. British and Continental manufacturers were well represented, but several Canadian exhibits showed the progress made by the Canadian machine tool industry.

In this connection, a particularly interesting machine was shown by Modern Tool Works Limited, of Toronto. This is the six-spindle special purpose machine illustrated, for bushing, coining, chamfering and drilling connecting rods. It employs three standard extra-light-duty hydraulic units, a hydraulic, rotary indexing table with six stations, and two vertical rams, all powered from a central source. The first working station presses the bushings into the wrist pin bore by a vertically mounted ram, the bushings being delivered to this station by two chutes discharging from a rotary hopper, the connecting rods having been previously loaded in pairs into a self-operating fixture. Inside diameters of the bushings are burnished with hydraulically-rammed bead broaches at the third station, and both ends of the bushing bore are chamfered simultaneously at station four by means of eccentric outfeeding recessing tools. The oil holes are spot-faced and chamfered with a horizontally mounted unit at station five, and are finally drilled through at station six. The fixtures are automatically unclamped during indexing to the unloading station. Details of the fixtures and tooling are illustrated below. The operator merely removes the finished assemblies and replaces them by new ones as each station reaches the loading station; clamping and unclamping are automatic. Indexing is not continuous and, as a safety measure, the operator must start each cycle by push buttons. It is not necessary for one cycle to be completed before starting another. The clamping of the connecting rods was rather a problem, as the drilled wrist pin hole had to be positioned physically without obstructing the operation



of the various tools. The fixture clamp operation is therefore arranged as a function of the machine, rather than of the operator, and it is possible to allow the connecting rods to remain unclamped at stations two and three. The crankshaft bore is anchored on a plug and the wrist pin end of the rods is floating. The fixture clamps come into operation simultaneously with the entry of the bead broaches at station three.

The machine has a production rate of some 600 components per hour.



THREAD ROLLING MACHINE

The " planetary die ' principle is used in the design of a high-output thread rolling machine, shown at the Canadian International Trade Fair, Toronto, and manufactured by the D.H. Prutton Machinery Company, of Cleveland, Ohio. The circular rotating die shoes revolve continuously inside two diametrically opposed stationary dies. The work blanks are supplied in a continuous flow by a dual hopper feed. The arc of the stationary die is calculated to apply the rolling pressure to the blank gradually, to avoid over-stressing and to extend die life. The blanks to be thread rolled are fed between the rolls vertically by feed fingers, and penetrate to their full length in about half the travel between the dies; the second half of the travel is used to produce full thread form and good finish.

The rotating die has a surface speed of 164 fpm and 8 threaded components are produced for every full revolution. Production output of up to 20,000 pieces per hour is claimed by the makers and the die life is said to be from 3 to 5 million pieces. The machine occupies a very small floor area and weighs only 2600 lb. It is capable of thread rolling up to $\frac{1}{4}$ in. dia. A larger machine, with a capacity of $\frac{1}{4}$ to $\frac{5}{8}$ in. dia., is also available and production rates of 9000 pieces per hour are claimed for it.

INSTRUCTIONAL LATHE

A British-built machine, which had its first public showing at the Canadian International Trade Fair, Toronto, was the " Student " 6 in. centre lathe, manufactured by the Colchester Lathe Company, Ltd., of

PHILIPS INDUSTRIAL HIGH FREQUENCY HEATING EQUIPMENT

Philips Electrical Limited manufacture a wide range of High Frequency Generators and allied equipment for Induction and Dielectric heating applications, ranging, in the case of Induction heating, from the large 160 kW. generator down to one of only 2½ kW. Philips extensive experience in many branches of industry has been utilized in the design and construction of these generators. Three popular models are described below:

F.280 (160 kW) Generator :

Max. Power output at terminals	160 kW	Cont
Max. Power required from Mains	300	kVA
Power Factor	0.9	
Mains Supply Voltage — 380/440v. 3-ph	50	cycles
Nominal Frequency	200	kc/s

F.50 (25 kW) Generator :

Max. Power at Terminals	25	kW
Max. Power required from Mains	50	kVA
Power Factor	0.9	
Mains Supply Voltage — 380/440v. 3-ph	50	cycles
Nominal Operating Frequency	350	kc/s

F.5 (2½ kW) Generator :

Max. Power at Terminals	2½	kW
Max. Power required from Mains	5	kVA
Power Factor	.85	
Nominal Operating Frequency	520	kc/s

Other Philips Generators available are :—

F.150 (80 kW) Induction Heating Generator
F.100 (50 kW) Induction Heating Generator
F.26 (14 kW) Induction Heating Generator
F.18 (10 kW) Induction Heating Generator
F.13 (6 kW) Induction Heating Generator
DF.1500 (750 W) Dielectric Heating Generator
DF.6 (3 kW) Dielectric Heating Generator.
All the above generators conform to BSS. 1799.

PHILIPS also manufacture a range of allied equipment including Work Inductors and Concentrators, Flexible Water Cooled H.F. Leads, H.F. Change-ove Switches, and Melting Units. For full information, please write to the address below.

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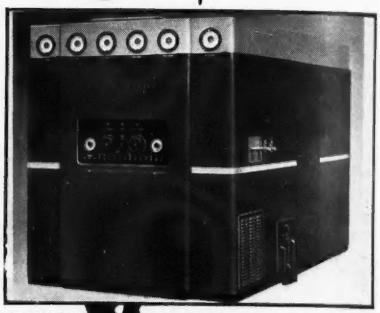
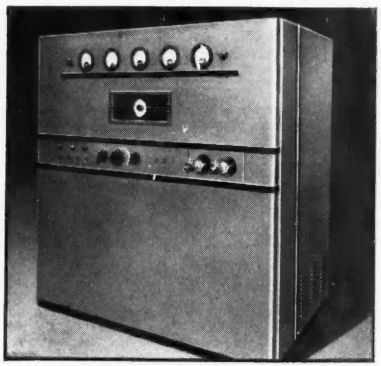


F.280 (160 kW) Generator: This is the largest valve-driven electronic heating generator in Europe, and its design incorporates the most modern features.



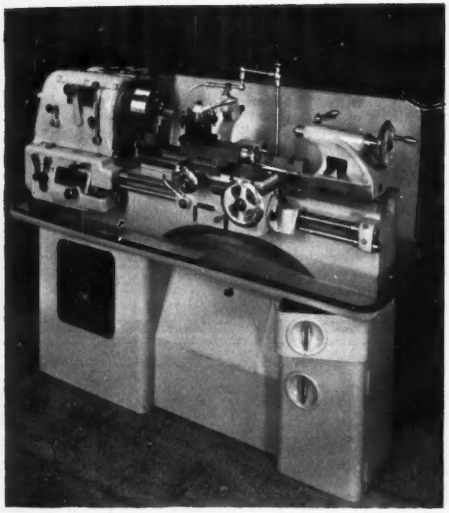
F.50 (25 kW) Generator: A medium-sized equipment which is in constant demand in many industries.

F.5 (2½ kW) Generator: Compact and extremely versatile, this low-powered equipment has proved increasingly popular.

(HF271)

Colchester, and marketed in Canada by their own subsidiary company.

The machine illustrated is primarily intended for instructional purposes in technical colleges, apprentice schools, etc., and incorporates several ingenious safety features. One of these is a special shear pin device in the change wheel train, which prevents damage to the train should the tool or tool-post be accidentally run into the headstock or tailstock when screw-cutting. Operation is easily resumed after the fitting of a replacement shear pin. In addition, the main motor is automatically isolated when the change wheel guard is removed. A similar safety switch is built into the main switch panel, so that the mains supply is completely cut off when the panel is removed for repairs. The switch panel also incorporates an overload release and no-volt control. The machine cannot be re-started after a power failure without re-setting the starting lever.

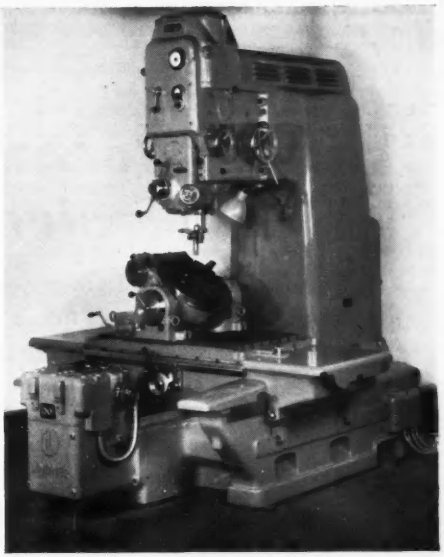


With the exception of these and other safety devices, the machine is of normal design, although it has an unusually large spindle bore of $1\frac{9}{16}$ in. diameter. The spindle nose, bed, and saddle are exceptionally rigid, so that the machine, although mainly intended for training purposes, is capable of relatively heavy machining. It is available as a straight or gap bed type and the main specifications are: Swing over bed, 12 in.; swing in gap, 19 in.; gap length, $4\frac{1}{2}$ in.; distance between centres, 24 in.; eight spindle speeds, from 52 to 1000 rpm; thirty-six feeds, from 0·004 to 0·068 in. per rev.; motor, $1\frac{1}{2}$ hp.

JIG BORING MACHINE

A jig boring machine, shown at the Third European Machine Tool Exhibition, Brussels, incorporates some interesting features: The optical setting incorporates a projection screen, so that the operator can read the scale accurately whilst standing erect. The optical setting device is also connected to an electrical indicator, which shows zero position when the exact table setting is reached, i.e., when the setting line is in the centre of the scale division line. This auxiliary device ensures that the setting is not subject to parallax errors and errors due to the human element.

Another useful feature is pre-selection of the next table position while a machining operation is still in progress. When the machining operation is completed, the pressing of a push button sets the table in rapid motion. This is automatically disengaged in the vicinity of the required setting, and final fine adjustment is then made by means of the optical and electrical setting devices.

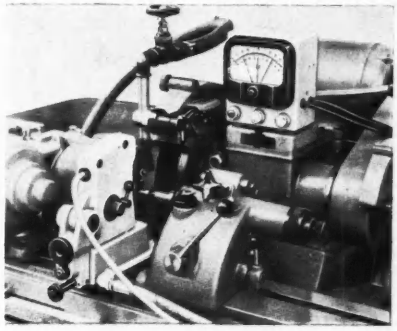


The pre-selector controls are built into the switch panel and incorporate illuminated scales for setting the required table travel. These scales have full millimetre divisions. Decimal settings are made on a precision scale and verniers. The selected direction of table movement is indicated by illuminated arrows, and as soon as the table comes to a standstill in the vicinity of the required setting, the optical projection scales become illuminated automatically.

ELECTRONIC DIAMETER CONTROL FOR GRINDERS

Automatic sizing and cycle control is not uncommon on cylindrical grinders, but an instrument which brings these possibilities to a conventional plain cylindrical grinder is unusual. The MOVOLIMIT C.R. 100 Electronic Diameter Control Instrument, manufactured by Movomatic S.A., of Neuchatel, Switzerland, and exhibited at the Third European Machine Tool Exhibition, Brussels, was shown mounted on a Studer hydraulic universal grinding machine, and consists of a measuring head, and an indicator with control relays and amplifier.

The base of the measuring head is mounted on the machine table, and the head itself, which can have either hydraulic or mechanical retraction, has a caliper system, with one fixed and one moving contact. The movement of the latter is electrically connected with the indicator and control relays, through the amplifier. The moving contact has fine and coarse adjustment, and the pressure



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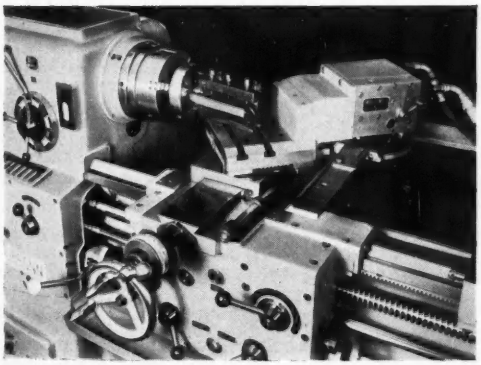
of the fixed contact against the workpiece can also be adjusted. The travel of the moving contact is 2 mm and the standard head has a capacity of 4-70 mm. The indicator has a scale with a main pointer and tolerance pointers, as well as three light signals. It also actuates the relay controlling the roughing cycle and a relay which retracts the measuring head and the grinding wheel. The amplifier, which can be conveniently located near the machine, also has a control panel with the main " on-off " switch and various other controls. The accuracy of the indicator reading is $\pm$ 2 per cent of the total value of the used scale, which can be either 5 μ or 50 μ, either side of zero. Diameter control accuracy is said to be either $\pm$ 0·4 μ or $\pm$ 4 μ, depending on the scale used. Voltage fluctuations have little or no influence on indicator accuracy.

LATHES AND TRACER TURNING ATTACHMENTS

The comprehensive range of lathes shown by Eugen Weisser & Co., of Heilbronn/Neckar, Germany, at the Third European Machine Tool Exhibition, Brussels, included the well-known " Goliath " high-speed lathe, the type PZ165 electrically-controlled high-speed production lathe, the model DLNE high-speed lathe, the model DV315 automatic multi-tool finishing lathe, and the " Panther " production lathe.

The " Panther " is a new development by Weisser Heilbronn. Basically akin to the " Goliath," the new lathe incorporates several innovations, including an electro-hydraulic pre-selector arrangement for controlling the 12 spindle speeds, ranging from 45 to 2000 rpm, a pre-selector for longitudinal and transverse feeds, and a multiple longitudinal stop arrangement for five or more positions.



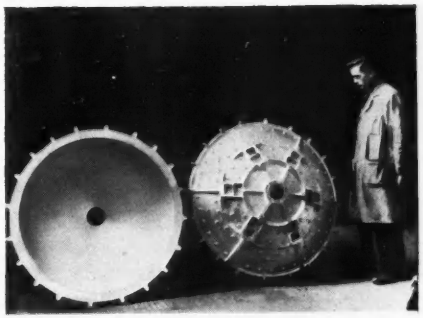
All lathes manufactured by Weisser Heilbronn, as well as those of other manufacturers, can be equipped with their newly developed hydraulic longitudinal and transverse tracer turning attachment, known as the " Multicop." Among the many advantages claimed for the " Multicop " attachment may be mentioned the following :—

(1) Smooth, stepless surfaces, as a result of continuous single tool cutting.
(2) Automatic control of working to measurement and elimination of the necessity for repeated measuring.
(3) Reduction of grinding allowance, and high machining accuracy, ranging from 0·0012 to 0·0016 in., depending on the shape of the workpiece.
(4) Elimination of the need for expensive profiled turning tools or multiple tool set-ups.
(5) Possibility of producing, in one uninterrupted cut, any desired combination of diameters, ascending and descending tapers, radii, profiles, grooves, recesses, and undercutting.
(6) Operation with masters or templates, which, owing to the minimum pressure exerted, do not require hardening.
(7) Mounting on the front of the lathe and not on the rear. The " Multicop " will not collide with a taper attachment mounted on the same lathe.
(8) Direct adjustment of feed by means of the normal feed box.

Transverse turning with this attachment mounted on a " Goliath " lathe is illustrated.

STRESS-FREE DIE CASTINGS

Stress-free castings produced by the Parlanti Mould Process, which embodies the use of " temperature-graded " anodised aluminium alloy dies, were shown at the S.B.A.C. Exhibition, Farnborough, by Carron-Parlanti Ltd. These Ni-forge castings possess a freedom from stress hitherto attained only in a forging. Furthermore, their homogeneous nature gives improved pressure-retaining qualities. They machine excellently and are particularly suited to the production of prototypes, owing to the ease with which the moulds can be modified.



The principal exhibit was the reflector casting illustrated, which measures 49 in. in diameter by 24 in. in depth, and weighs 550 lb as cast. Other exhibits included compressor blades, aircraft tip-sections, male and female couplings, and many other castings in the aluminium range of alloys to specifications 3L33 and DDT 133C/304/424/300A.

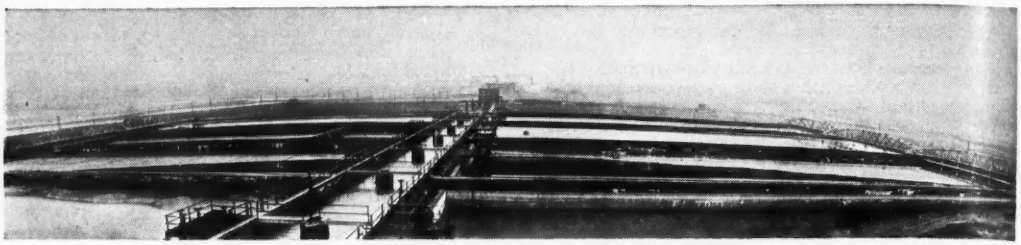
STARTER FOR TURBINE ENGINES

Among the range of aircraft equipment shown at the S.B.A.C. Exhibition, Farnborough, by The Plessey Group of Companies, of Ilford, an item of primary interest is their liquid fuel starter for turbine engines, type LTS 70, stated to be a considerable advance over the cartridge type turbo-starter.

The present exhibit, designed for engines requiring an average starter power of 70 hp, is the first unit of this type to have completed bench type approval tests to Ministry of Supply Specification. Another unit, the LTS 150, designed for engines requiring an average starter power of 150 hp, has also been developed.

The fuel used is iso-propyl nitrate. A mono-fuel, it does not, under suitable conditions, require air or other oxidants to decompose. The simplest and lightest systems of pumping and control can therefore be utilised.

Classified by the British Home Office as a safe fuel, iso-propyl nitrate is not shock-sensitive, is non-toxic, and, at atmospheric pressure in the presence of air, combustion can readily be extinguished either with water or CO_2. It is available in adequate quantities at low cost, the cost per start for engines in current use being approximately four shillings, as compared with twenty-five to thirty shillings per start in the case of a cordite starter.



The World's Largest Sewage Sludge Scrapers

-and in DURALUMIN 'H'

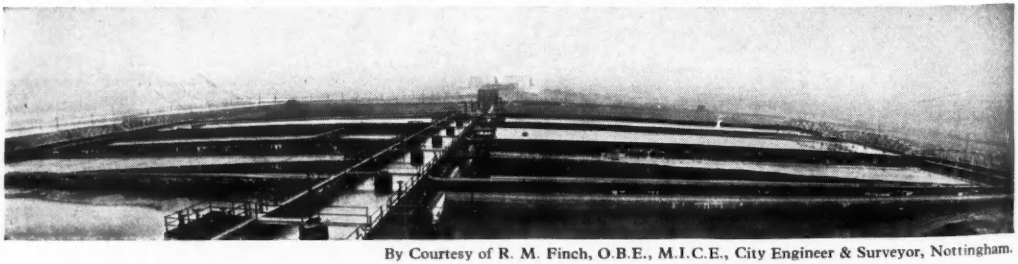
REGD. TRADE MARK

These six sludge scrapers at the Nottingham Corporation Sewage Disposal Works each have an overall span of 114ft. 4½ ins., and the total weight of Duralumin 'H' extruded section and plate used is 21 tons. Messrs. Thatcher Lucas & Co. Ltd., of Great Bridge, Tipton, Staffs, were the contractors, and the installation is the largest of its kind in the world.

Sewage equipment is only one example from an increasing number of new applications for 'Duralumin' that have been developed in recent years. This alloy is one of a large range manufactured by James Booth & Co. Ltd., of Birmingham, and our Development Department will be pleased to discuss their use for any purpose entirely without obligation.

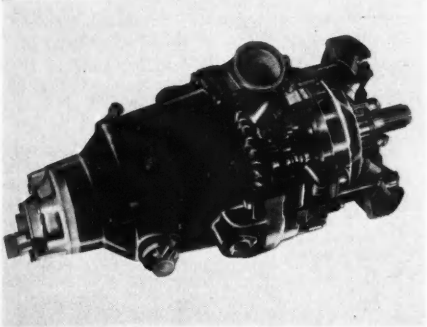
BOOTH BIRMINGHAM

JAMES BOOTH & COMPANY LIMITED · ARGYLE STREET WORKS · BIRMINGHAM 7



By Courtesy of R. M. Finch, O.B.E., M.I.C.E., City Engineer & Surveyor, Nottingham.

A still further increase in the intrinsic flexibility of this new system can be achieved on multi-engined aircraft by fitting each engine with a separate starter motor. A common pumping and control system, with suitable switching arrangements for starting each in turn, is provided. A considerable saving in weight results from this arrangement, even though, on the comparative basis of a three-start system, a liquid fuel starter is already lighter than any other self-contained starting equipment. Illustrated is a sectional perspective view of the turbine motor unit used in this system.



Operation is by push button from the cockpit, the cycle being automatically controlled by a special control panel.

Air is first supplied from the pumping unit to the combustion chamber for scavenging purposes. Fuel is then delivered and the resulting air/fuel mixture is ignited by sparking plugs energised by a special high-frequency ignition unit developed by D. Napier Limited and the Plessey Company Limited.

This new ignition system possesses several advantages. Among them is the fact that, operating within the voltage range 18-24 volts d.c., it is virtually instantaneous in action, the time delay between energisation and production of the first spark being of the order of 10 milliseconds. Discharging even through caked or flooded plugs of the gapped type, and giving 1·5 joules of energy per spark, its repetition rate of 50 per second, provides what is virtually a continuous action. An additional advantage is that the energy is not stored at lethal voltage level.

In view of these points in favour of this ignition system, it is now being developed for many other applications, including the re-lighting of gas turbines at altitude, and various purposes involving the ignition of crude oil.

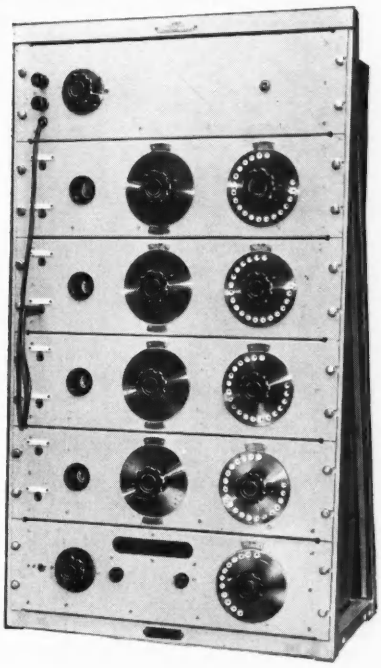
PRECISION FREQUENCY-MEASURING EQUIPMENT

A new piece of apparatus, exhibited at the S.B.A.C. Exhibition, Farnborough, is the G.E.C. precision frequency-measuring equipment manufactured by Salford Electrical Instruments Ltd., of Salford, by means of which even an unskilled operator can make precision measurements by direct reading.

The range of the equipment extends from 10 cps to 10 Mcs and the accuracy of observation is better than 1 cps, plus the error of the source of standard frequency.

The general principle of operation is to heterodyne the unknown signals with a selected series of standard frequencies, chosen from a standard decade series in descending order of magnitude, until a residual frequency less than 1 kcs remains. This is then measured on a frequency meter stage having a discrimination better than 1 cps. By a special design, the digits defining the unknown frequency are automatically selected in the course of a measurement and the appropriate figures are illuminated at the end of the measurement.

A measurement is carried out in stages in the following manner :—First, the unknown signal is tuned in on the appropriate stage. Correct tuning is facilitated by means of a "magic-eye" tuning indicator. The setting of the tuning dials indicates by means of a code letter the correct setting of the standard harmonic selector dial, which is then turned to the proper position. When this has been done, a digit representing the first digit of the unknown frequency is illuminated and the beat frequency formed by the unknown signal and the selected standard harmonic is passed on to the next stage. This procedure is repeated digit by digit until a frequency less than 1 kcs remains. The frequency meter stage then measures this frequency in two stages : The whole signal is measured and the value indicated on a galvanometer scale ; a switch similar to the harmonic selector switches is then adjusted to a position corresponding to the first digit of the low frequency. The galvanometer, which has a scale of 100 divisions corresponding to 100 cps, then indicates the value of the remaining two digits.



Also exhibited by Salford Electrical Instruments Ltd. were the first production models of three standard sizes of wire-wound toroidal potentiometers from 2¼ in. to 3¾ in. diameter with 340 deg. angle of sweep. Their power ratings are up to 8 W, with a resistance range from 1000 ohms to ½ megohm. Windings are linear to within a tolerance of 0·1 per cent.

Other instruments included a new miniature multi-range link testing ammeter, a new link testing power-factor meter, and a radio altimeter giving direct instrument reading of height above the ground from 50 to 5,000 ft, without any manual range switching and with an accuracy of 3 ft ± 3 per cent.

ERRATUM

In our description, on page 302 of our August issue, of the "Habit" Radform universal radius generator, the range of this instrument was inadvertently given as 0·0005 in. to 0·5 in. This should have read 0·005 in. to 0·5 in.

TAYLOR-HOBSON

MODEL 3 'TALYSURF'

Surface Measuring Instrument

Here is tried, tested, proved Surface Measuring equipment which has won approval the world over! It possesses the refinement of the laboratory instrument, but combines the serviceability essential for everyday workshop usage.

Model 3 'Talysurf' will cope with a specimen 9½" diameter, if unsupported by vee-blocks, and by using the Datum Attachment accessories will equally accept a specimen such as a watch pivot of 1/16" diameter at the largest end, and provide a graph record down to its tapering end. These two extreme examples demonstrate exceptional capacity. No better instrument is available. Conforms to British Standard Specification No. 1134 of 1950. Ask for List No. TH 204-7.

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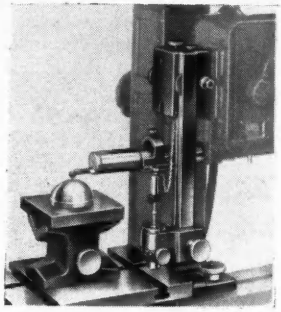
Leicester, England.



DATUM ATTACHMENT

Datum Attachment increases 'Talysurf' uses, as means for measuring radii Convex or Concave, Chatter and Waves (as distinct from roughness) and for narrow surfaces, e.g., piston rings, watch parts and very small components.

CLASSIFIED ABSTRACTS

Numerous important abstracts which, for lack of space, cannot be published in our main editorial columns, are regularly included in condensed form in this section. Subscribers may obtain photostat copies of all original articles at cost.

CHEMICAL ENGINEERING

Cracking Catalyst Activity in the Presence of Hydrogen Sulphide

By H. A. DIRKSEN, H. R. LINDEN, and E. S. PETTYJOHN. (From *Institute of Gas Technology Research Bulletin, U.S.A.*, No. 4, February, 1953, 28 pages, 20 illustrations.)

CATALYTIC cracking of propane and other hydrocarbons of low molecular weight, especially natural gas, has achieved industrial importance as a method of producing utility gases. Emergency conditions, economic factors, or depletion of hydrocarbon sources may necessitate charging sulphur-contaminated stocks, materials which are not at present usable, on account of loss of catalyst activity due to sulphur " poisoning."

A search for a highly active, sulphur-resistant catalyst for cracking propane was conducted among the many known catalysts for related reactions. Nickel, iron, and cobalt of Group VIII, chromium, molybdenum, and tungsten of Subgroup VIa, and vanadium, columbium, and tantalum of Subgroup Va, with thoria and zirconia of Subgroup IVa as promoters, were prepared in sulphide and oxide forms on various supports in a standard 1 to 3 mole ratio of catalytic substances to support, and in other ratios, and subjected to a " standard " test procedure, to measure their activities with and without the addition of sulphur in the form of H_2S.

Nickel in its various forms was found to be the most promising catalyst for the steam-propane reaction, followed by molybdenum. Iron, chromium, and cobalt were generally less active. The sulphide forms of these catalysts were normally more active in the presence of H_2S than the corresponding oxide forms.

A study of the effect of molar concentration of catalytic material to support material indicated that an optimum catalyst-to-support ratio existed. Additional studies showed that mixed catalysts tended to afford no improvement in activity over that of the higher activity component, but that they had a somewhat greater sulphur-resistance.

ELECTRIC MOTORS

Impulse Tests on High-Voltage Motors

By J. ALLE and F. DESCANS. (From *ACEC-Charleroi, Belgium*, No. 1, 1953, pp. 29-39, 15 illustrations.)

THE use of asynchronous motors of medium rating at high voltage (6000 V) has given rise to a number of faults usually attributed to transient over-voltages. Research, to ascertain the reasons for these faults, was directed along two distinct lines :—(1) The study of the origins of the stresses, especially those related to the operations of switching-on and disconnecting ; and (2) analysis of the stresses occurring in the windings of these motors, when subjected to an impulse wave test. This latter aspect only is dealt with in this article, which is concerned with the results of research on the following lines :

(a) Study of the penetration of the impulse wave into the winding of the motor, effected by means of a repeating impulse generator.
(b) Tests at reduced and at normal voltage, to determine the criteria to apply to these faults.
(c) Tests at high voltage, carried to the breakdown point, with a discussion of the criteria to be applied in this case.
(d) Determination of the optimum characteristics of an impulse testing station specially designed for tests on motors, on the basis of the data assembled from the above tests and the conclusions to which they lead.
(e) The inception of an impulse testing station.

FLOW MECHANICS

Three-Dimensional Laminar Boundary-Layer Flow

By F. M. MOORE. (From *Journal of the Aeronautical Sciences, U.S.A.*, Vol. 20, No. 8, August, 1953, pp. 525-534, 10 illustrations.)

TECHNIQUES for predicting the steady plane laminar flow of a viscous fluid are reasonably well developed. Interest in aircraft applications has centered attention on the boundary layer, to which the frictional and dissipative effects of viscosity are confined, and beyond which the fluid behaves in a non-viscous manner, substantially unaffected by the presence of the boundary layer.

In this paper, the possibilities of predicting steady three-dimensional boundary-layer behaviour are inferred from detailed consideration of the case of a cone at angle of attack to a supersonic stream. Qualitative features of the cone boundary layer are discussed, and solutions are presented in which (a) angle of attack is assumed to be small (a method of perturbations), thickening of the boundary-layer on the lee side of the cone is indicated, but no separation of the cross flow occurs ; and (b) consideration is restricted to the plane of symmetry of the flow, with no restriction on angle of attack. On the lee side of the cone, unique solutions are limited to small angle of attack, and, beyond a certain angle of attack, the boundary layer cannot remain thin.

The concepts of displacement thickness and flow separation are generalised to three dimensions, and failure of the thin boundary-layer assumptions is related to the formation of strong vortices in a separated region, for laminar, or more tentatively, for turbulent flow.

MACHINE SHOP PRACTICE

Economical Methods of Dimensioning Round Stock by Bar Peeling Operations.

By H. MAKELT. (From *Werkstatt und Betrieb, Germany*, Vol. 86, No. 7, July, 1953, pp. 325-334, 20 illustrations.)

FOR dimensioning round stock to close tolerances, the material can either be drawn on drawing benches or turned (peeled) by rotating cutters. The shaft feed of such peeling machines has been considerably increased by improved design and by the use of carbide-tipped inserted blades. Additional advantages resulting from the cutting operation are : Absence of stresses in the peeled material, as compared with material drawn on benches ; removal of cracks in the surface ; improved accuracy of shape ; elimination of need for preliminary pickling of the shaft ; and good machinability of larger diameters of work and materials of high tensile strength.

Owing to its special shape, the turning cutter ensures a smooth non-vibrating cut, and the turning

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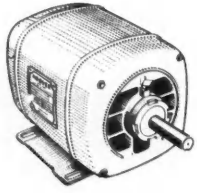

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INDUSTRIAL PRODUCTS DEPARTMENT

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operation can be supplemented by burnishing, if desired. The method of tooling by cutters with inserted tangential blades constitutes progress in a design which lends itself particularly to the physical properties of carbide tool material. Resharpening of tangential tools within close tolerances is very easy, as only one face of the tooth must be reground, thereby preserving the profile.

The modern peeling machine, with infinitely variable speed adjustment, is usually flanked on one side by the shaft feeding mechanism and on the other side by the discharge mechanism. Remote control from the operator's stand is frequently incorporated in these mechanisms. The cutting speed of these machines ranges from 15 to 165 fpm, thus covering all kinds of work and tool material. All data required for peeling of round stock can be readily calculated from tables, based on extensive research work. Tests on tool life, carried out with carbide-tipped tangential blade cutters, have proved very satisfactory.

METALLURGICAL ENGINEERING

Failures in High-Temperature Alloys

By W. E. JONES. (From *The Iron Age, U.S.A.*, Vol. 172, No. 2, July 9, 1953, pp. 137-141, 7 illustrations.)

DEVELOPMENT of good high-temperature alloys has progressed rapidly in recent years, particularly in the case of jet engine applications ; however, even higher temperature alloys will be required in the future, and the nature of high-temperature failures must be recognised, if they are to be overcome and better high-temperature materials developed.

Failures due to stress rupture can be observed in many high-temperature components. The tendency to stress rupture failure can be accelerated by cyclic temperature conditions and by occasional hot starts, with instantaneous, but extremely high, temperatures. Many small cycles or a very few cycles do not seriously reduce the steady state rupture strength.

Cold working can have an appreciable effect on the rupture strength. This effect is observed in rupture tests at temperatures below which recrystallisation can occur. Jet-engine buckets are an example of the effects of cold work on metals at elevated temperatures. The base of the bucket can be strengthened by shot peening ; the blade portion, however, may be above the recrystallisation temperature, so that every effort must be made to protect it from any cold work. Cutting, grinding, and polishing will produce severely cold worked layers 0·001 to 0·002 in. deep on the surface of the part.

Fatigue strength is another factor in the high-temperature performance of metals, on account of the possibility of resonant vibration. Fatigue strength is lowered by increasing temperatures. The temperature also relieves the residual stresses, so that an actual increase in fatigue strength may be observed in a tensile-stressed specimen as the temperature increases.

The effect of notches on high-temperature failures is important, because notches greatly affect strength properties and parts cannot be manufactured which are free of them. Notches also have a considerable effect upon high-temperature fatigue strength.

Oxidation resistance has not been a serious problem in the past, as changes could be made, where required, to the stainless or heat-resisting alloys. However, it will become more of a problem in the future, particularly if molybdenum or molybdenum-base alloys come into greater use. With this material, the oxidation rate is extremely high, compared with that of the regularly encountered alloys, so that protective coatings are required. Because of the nature of the oxidation, the coating must be completely continuous ; otherwise, oxidation will not be stopped. Considerable efforts are being made to solve this problem, as molybdenum offers great promise as a higher temperature alloy.

WELDING

Electric Arc Welding of Cast Iron with Cast Iron Electrodes and a Granulated Charge

By A. I. ZELENOV. (From *Avtogennoye Delo, Russia*, April, 1953, pp. 7-9).

As practised to-day, electrical welding of cast iron, particularly with cast iron electrodes, does not give altogether satisfactory results for strength, density, uniformity, and machinability of the welding seam.

The author has developed a method for welding repairs in cast iron components, using electrodes of ordinary grey cast iron with a stabilising coat of chalk. In this method, a granulated compound is introduced into the welding bath, which consists of the following components : Cast iron chips, steel chips, ferrosilicon, and (occasionally) graphite and aluminium.

A typical welding repair operation, in which a crater resulting from a casting fault has to be filled up, proceeds as follows :—The natural surface of the crater is smoothed by means of a chisel. The crater is banked with an asbestos strip to prevent overflow of the welding bath, and to give the welded-on metal the necessary form. Welding is carried out with an electrode of 8 mm diameter and a welding current of 360 A. The granulated compound is made up of cast iron chips 48 per cent, steel chips 6 per cent, and ferrosilicon 12 per cent, by weight. The component is so positioned that the surface around the crater is horizontal. The welding is completed in three layers. After welding, the component is cooled slowly in heated sand. The Brinell hardness of the welded-on metal is found to be about 230.

The method so described produces sound welds for repairs, filling-in, and building-up, of cast iron components. The welds are very similar to the parent metal in their physical and chemical properties and permit machining by cutting tools. Welding can be carried out with a.c. or d.c., with cast iron electrodes of ordinary quality. This method is claimed to be faster than other methods of cast iron welding.

THE DESIGN OF LARGE STEAM TURBINES IN CZECHOSLOVAKIA

(*Concluded from page* 334)

indicator designed for this purpose is fitted to the bearing pedestal, and its piston is in constant contact with the end of the rotor *via* an oil film. The differential piston of this indicator has, in its larger area, a small bore through which the pressure oil passes to the other side of the piston, and thence through a central bore to the turbine rotor. By means of the oil thus issuing, the piston remains in constant contact with the rotor. This movement is transmitted through a linkage to the pointer of the indicating instrument, on the scale of which there are two electrical contacts, the pointer acting as a switch.

The first contact, corresponding to a rotor elongation of 0·04 in., actuates a signal which warns the attendant. For an elongation of 0·08 in., the second contact switches on an electromagnet, which, in turn, actuates a trip gear. As the axial clearance in the glands is 0·1 in., and in the blading 0·12 in., damage due to excessive elongation of the rotor is avoided.

In addition, there are safety devices for oil pressure and vacuum. Both are pressure-controlling devices operating through two limiting stages, the second of which actuates the electromagnet already mentioned. These safety devices do not allow the turbine to gather speed on starting, unless there is sufficient oil pressure and vacuum. The electromagnet also receives an impulse from the tachometer. An adjustable electric contact, when set to 3300 rpm, enables the tachometer to act as an emergency governor.

It is also worth noting that a liquid-level indicator is installed, giving warning of both maximum and minimum levels of the hotwell.

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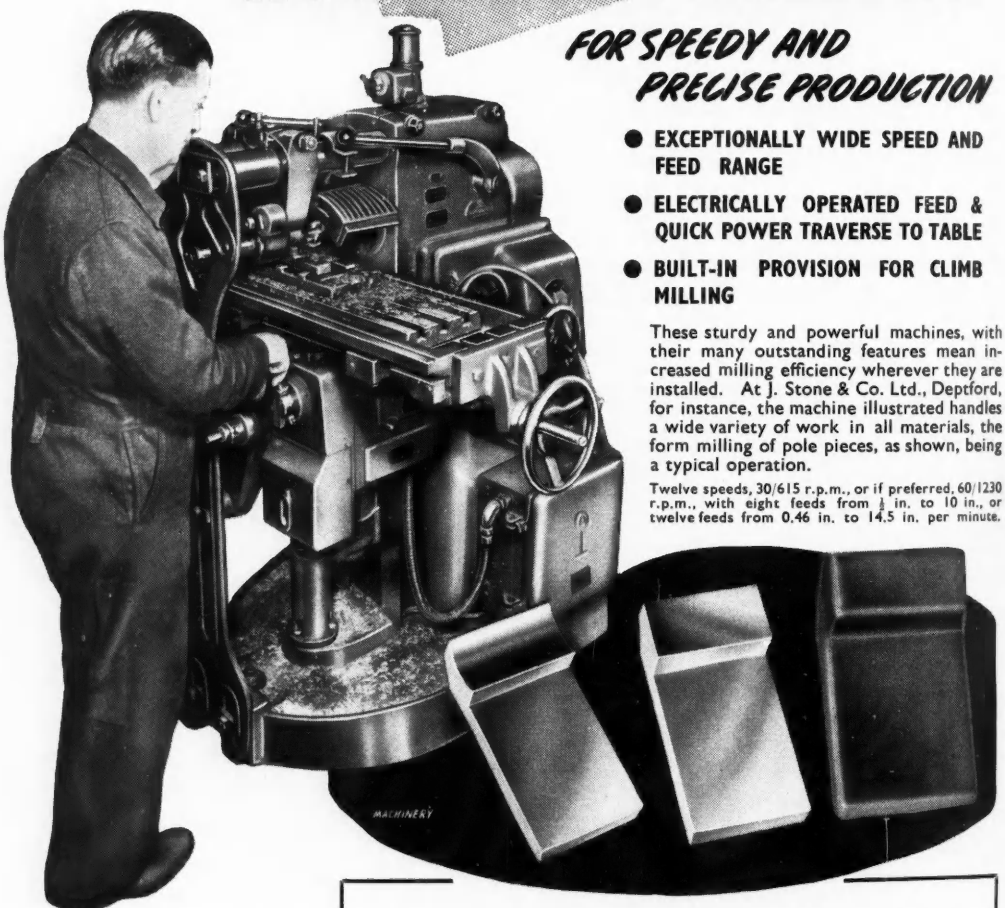

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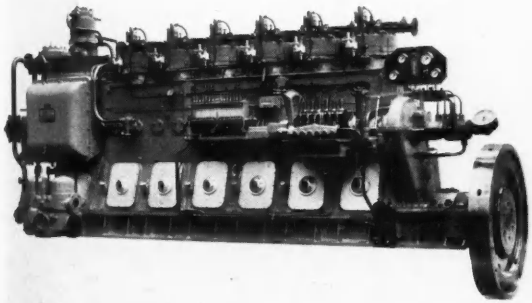
ENGINEERING MARINE & WELDING EXHIBITION

& THE CHEMICAL PLANT EXHIBITION

Our August issue contained a preview of some of the interesting products exhibited at Olympia, London. This month a further selection of exhibits is presented.

The British Polar M46I engine, illustrated, exhibited by **British Polar Engines Ltd.,** of Glasgow, is a self-contained unit, complete with engine-mounted lubricating oil cooler and filter. Bore is 250 mm, stroke 420 mm, and it is designed to develop 600 bhp at 400 rpm. This engine is being used increasingly in a new application for geared propulsion, two or more engines being connected to a single shaft and geared together by one set of controls. The simplicity of the operating gear of this engine is an outstanding feature.



Another unit exhibited is the K46E marine auxiliary generating set, which incorporates an engine designed to develop 340 bhp at 600 rpm. This drives a 200 kW generator, and the set is specially designed to operate without transmitting vibrations to the surrounding structure. Great care has been taken to ensure perfect balancing, and anti-vibration mountings are fitted, so as to isolate the engine and generator from the foundation.

An interesting range of exhibits is displayed by **Bolinders,** of Sweden, in conjunction with their associate Company, **Messrs. A/B Penta,** and through the medium of **Bolinders Company Limited,** of London.

Messrs. A/B Bolinder-Munktell are concentrating on their new series of direct injection, totally enclosed, compression ignition four-stroke engines, including their new design models 1051 and 1052 single and two cylinder industrial diesels, complete with pulleys.

Three-cylinder models, developing 33 bhp, are also featured. These are in varying assemblies, as follows :

Model 1053 *I :* An industrial engine, with fan and flywheel for direct coupling.

Model 1053 *K* (21) *:* As above, but with fan, radiator and grill, fuel tank, and canopy, and mounted on cast iron bearers. This model (illustrated) is provided with a free shaft end for flexible coupling or pulley.

Model 1053 *PU :* A compact and sturdily designed pumping set, with direct flanged single-stage pump, having an output of 220 gpm at 90 ft head. This unit, complete with radiator, fan, and fuel tank, has a special instrument panel, showing quantity and pressure of water delivered.

Model 1053 *BR* 77 : Marine oil engine, developing 33 bhp at 1500 rpm. Fitted with heat exchanger, sea-

water pump, bilge pump, electric starting with auxiliary hand starting, and a substantial, oil-operated reduction gear, giving a propeller speed of 600 rpm.

Model 1053 *G :* 33 bhp at 1500 rpm. Oil engine, fitted with baseplate, and directly coupled to an ASEA alternator of 27·5 kVA, 50 cycles, three-phase current.

Also featured are the Model 1054 K 23, 4-cylinder industrial engine, developing 44 hp at 1500 rpm, and a comprehensive range of PENTA diesel, petrol, and paraffin engines, for marine and industrial applications.

The display arranged by **John I. Thornycroft & Co. Limited,** of London, covers many of their products, all of considerable interest to those concerned with ship and boat building and with the engineering industry in its various forms.

Page Four
INFORMATION SHEETS for the PRODUCTION ENGINEER
DRAWING COMPOUNDS
Processes which involve the drawing of metal create problems in the easing of its flow. A Drawing Compound is needed which acts partially as a lubricant to prevent die damage and yet permits controlled friction so that the metal will follow die contour under pressure. It is in this way that the Compound should aid the drawing operation.
Characteristics of a good Drawing Compound are:
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SEPT. 3rd–SEPT. 17th 1953
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Our Drawing Components embody these very desirable features and fulfil modern requirements.
We have available a suitable grade of Drawing Compound for each operation —light, medium and severe; ferrous and non-ferrous metals, including the light alloys.
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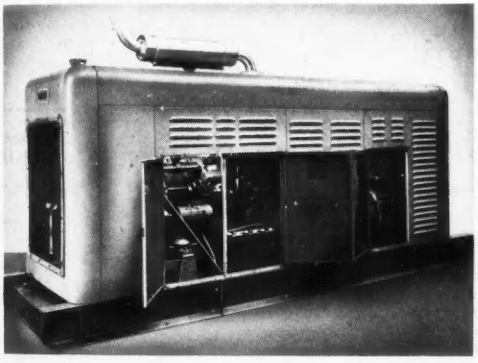
In the field of liquid fuel burning equipment, the latest type of burner is shown, fitted on a typical boiler furnace-front, a separate unit being available to demonstrate its operation in detail. A feature of this new unit is a device which makes it impossible to turn on the oil to any sprayer holder from which the sprayer has been removed or is not properly clamped in the correct working position.

Also shown is a side-by-side installation of two Thornycroft water-tube boilers in model form, thereby enabling their special features to be easily appreciated. These and other types of boilers are produced for naval and commercial vessels, as well as for land installations.

Thornycroft marine diesel engines for the smaller classes of commercial and pleasure craft are available in powers from 20 to 125 bhp. The unit exhibited is the RTR4 type 4-cylinder direct-injection unit developing 30 bhp at 1,750 rpm and fitted with a 2:1 reducing gear.

This model is arranged for hand starting and has a 24 V dynamo for charging the battery for radio and searchlight. An oil-operated reverse gear of the Self-Changing Gear Company's design may be fitted to the RTR4 engine as an alternative to the standard gear.

Industrial sets are produced in considerable numbers by Thornycroft for generating power for ships' emergency or auxiliary lighting for various purposes, as well as for pumping, air-compressing, and propelling or operating earth-moving plant.

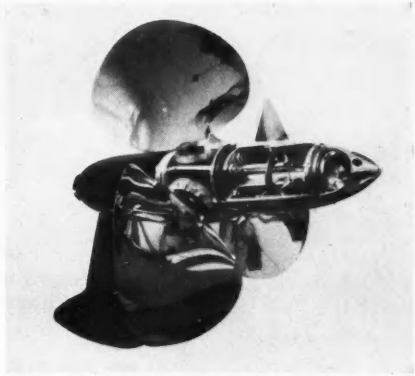


The equipment illustrated is a self-contained, semi-portable electric generating set for lighting and power, comprising a Thornycroft 6-cylinder diesel engine, type NR6/MV, direct coupled to a G.E.C. alternator, 400/230 V, 3 phase, 50 cycles, 52 kW at 1,500 rpm.

An interesting item, exhibited by **Rotol Limited,** of Gloucester, is the sectioned high-speed launch propeller illustrated. This is a typical 36 in. diameter Rotol controllable-pitch propeller for such high-speed craft as air/sea rescue launches and motor torpedo boats. The propeller has been sectioned to lay bare the internal pitch-changing mechanism, which consists of a hydraulically operated piston linked to the blades in hub sockets. Thus, linear movement of the piston is converted into rotary movement of the blades. This principle of operation is used on all Rotol marine propellers, and is adapted from the firm's aircraft propeller technique. Rotol controllable-pitch marine propellers generally have a total pitch range of 110 deg. from 90 deg. ahead (or feather) to 20 deg. astern. Rate of pitch change is 10 deg. per second.

Rotol began adapting its proved aircraft propeller technique to marine usage in 1941, of which one of the main features was that the engine speed and propeller pitch was controlled through a single lever and maintained by a constant-speed unit.

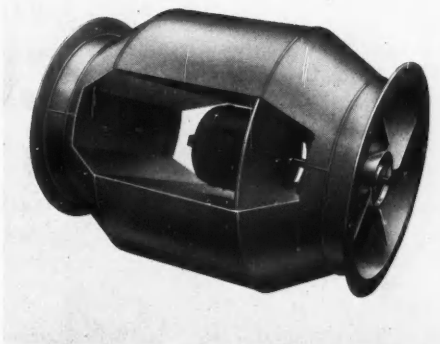
The constant-speed unit contains spring-loaded flyweights which are sensitive to changes in engine rpm.



In response to such alterations, the flyweights actuate a selector valve, which admits pressure oil to the Rotol propeller pitch-changing mechanism, either to coarsen or to fine-off blade pitch.

The governed rpm setting is altered simply by moving the control lever, which, in turn, alters the loading on the flyweight spring. The range over which the engine is governed is from full power ahead down to a predetermined level, when the governing mechanism becomes inoperative and the selector valve is manually controlled. This power level is usually the position where the maximum power required in the manoeuvring and astern range is prevalent.

Among the comprehensive range of fans exhibited by **Keith Blackman Limited,** of London, an interesting item is the " Tornado " 16 in. bifurcated fan illustrated. It is primarily designed for exhausting fume-laden air, dust, or gases, but obnoxious, corrosive, or inflammable gases can also be dealt with, by virtue of the bifurcated fan casing, with the motor completely isolated from the gas or air stream, and open to atmosphere. The fan, which has a capacity of 1250 cfm, is easy to instal, the gas or air stream being through the unit coaxially with the pipe line, of which it forms an integral part.



A similarly constructed unit is the " Tornado " 12 in. insulated fan, with a capacity of 610 cfm. This is also of the bifurcated type, but, in order to be able to handle duct temperatures of up to 350° F, the motor chamber is lined with asbestos.

Mention must also be made of a range of marine pattern axial and centrifugal fans, ships' hold ventilators, high-temperature centrifugal fans, blowers, air compressors, propeller fans, and portable fans for use in cooling hot spots in such places as iron and steel works, glass works, gas works, and foundries.

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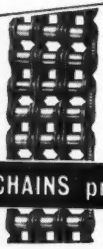

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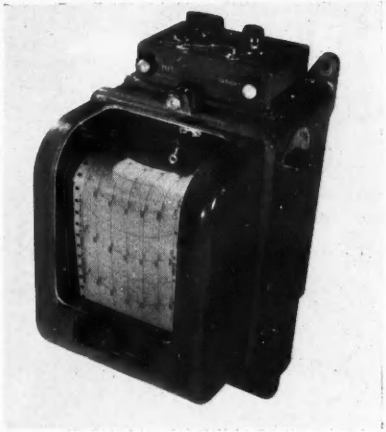
An interesting exhibit of the **Submarine Signal Company (London) Ltd.,** of Watford, is the " Subsig," Type 101, echo-sounding recorder.

Recordings are effected on dry electrolytic paper, upon which depth and time of calibrations are already printed. Recorded soundings are clear and permanent ; they do not fade and the paper does not shrink. Notes may be made on the paper in ink or pencil, and a " fix-marker " is provided. New rolls are easily inserted, the paper carriage being quickly swung out. Illumination of the paper is provided, and the previous hour's soundings are always visible, without the necessity for opening the instrument case.

The paper-moving mechanism is of extremely simple and robust design, and the combination of this movement with the strong, dry paper used ensures freedom from anxiety about the paper feed or the possibility of its tearing.

The recorder scales are from 0-120 ft, 0-120 fathoms, 80-200 ft, and 20-200 fathoms. These scales have been arranged to provide an overlap on either side of the " 100 fathom line," and the change from feet to fathoms is instantaneous, being effected by a crashproof gearbox.



The internal design of the instrument provides full shielding, to eliminate interference, and valves, motors, capacitors, etc. are operated well below rating. The controlling switch has an OFF and two alternative ON positions, one for the 0-120 phase, and the other for the 80-200 phase. The gear change switch, seen in the illustration at the right of the case, selects either the " feet " or the " fathoms " recording system, and thereafter the action of the equipment is entirely automatic.

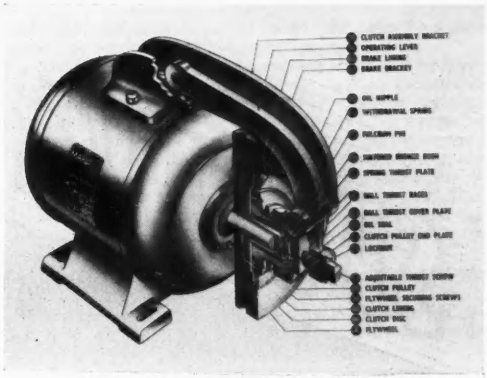
With this recorder, the paper feet rate is 6 in. per hour, the length of the chart roll is 50 ft, and the operation time per roll is 100 hours.

The D.I. type Mardrive Clutch Motor, exhibited by **The Marine Engineering Co. (Stockport) Ltd.,** of Stockport, is a further advance on the standard Mardrive Clutch Motor.

The essential features of all Mardrive Clutch Motors are the continuous running rotor and flywheel assembly, with which is engaged the combined clutch and pulley member for effecting the drive to the driven machine by means of Vee belts.

The general arrangement of this D.I. design is illustrated ; it will be seen that the clutch takes the form of a flat clutch plate carried on the rear face of the clutch pulley, which in turn is mounted on the flywheel with a sintered bronze bearing interposed between the two members.

Engagement of the clutch is effected by actuation of the clutch operating lever which, when released, allows the internal spring to engage upon the internal ball thrust

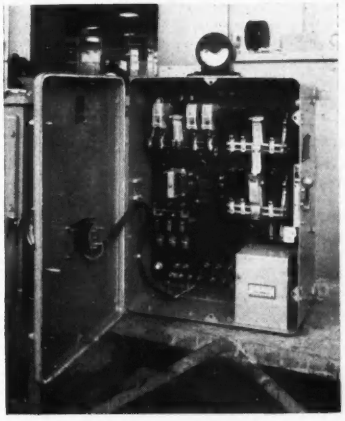


race and thus disengage the clutch faces, at the same time engaging the outer face of the clutch plate with the brake lining carried on the rigidly mounted brake bracket.

It will therefore be appreciated that extremely rapid engagement and disengagement of the drive can be effected by direct mechanical linkage or by remote control with solenoid operation. A further means of operation, which is rapidly gaining favour with many industries, is a Bowden cable connection to either a foot treadle or a hand lever incorporating a ratchet control.

A representative range of standard and special design motor control equipment for industrial and marine service, is being exhibited by **Brookhirst Switchgear Limited,** of Chester.

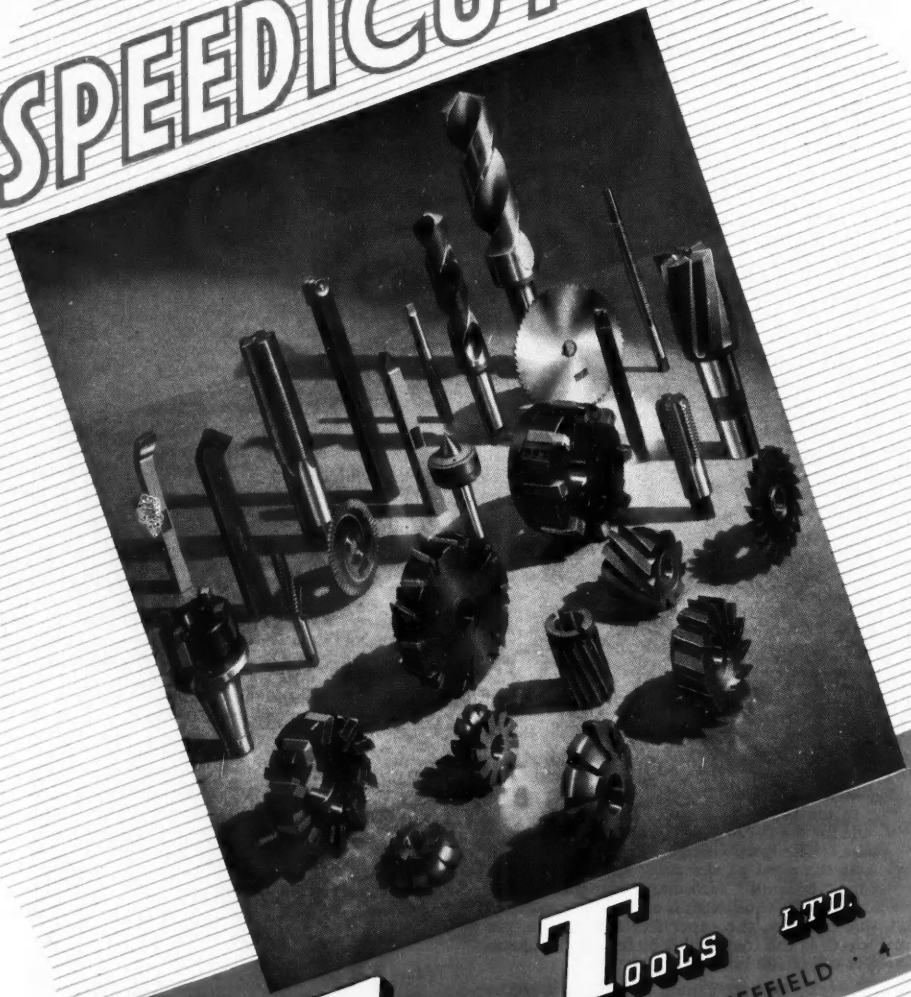
In the industrial field, typical " Simple Range " starters are the 7½ hp 400/440 V a.c. automatic straight-on starter, and the 17½ hp 400/440 V a.c. automatic star-delta starter, illustrated. The " Simple Range " comprises a.c. and d.c. starters of nearly all types and sizes and includes gears for hand and automatic operation, for wall and floor mounting, and for local or remote control. Adaptability is a feature of these designs, provision being made for the inclusion of many extra features to meet specific requirements, not usually available in standard equipment.



A special exhibit is a section of the " Unibord " multi-motor control board for heavy industrial use. This sturdy, metal-clad control board is built up entirely from standard busbar-mounting units, all of which are of the same width and interchangeable.

For marine applications, a selection of new design a.c. and d.c. marine starting equipment is exhibited, including basic and comprehensive types of straight-on starters for use with squirrel cage motors, 3-phase, 50/60 cycles.

SPEEDICUT



FIRTH BROWN TOOLS LTD.

SPEEDICUT WORKS · CARLISLE STREET, EAST · SHEFFIELD · 4

One such type is a 7½ hp 400/440 V basic type straight-on starter. This simple, compact unit comprises a T.P. main contactor, T.P. solenoid overload trips, T.P. isolator, two rewirable control circuit fuses, and local "start" and "stop" push buttons. The enclosure is a drip-proof, bulkhead mounting, metal case.

Another example is a 27½ hp 400/440 V comprehensive type straight-on starter. In addition to the main components, provision is made in comprehensive type starters for extra features, e.g., a voltage transformer for the controls. Other optional features include ammeter, pilot lamp, H.R.C. control circuit fuses, weather-deck watertight enclosure, etc.

A wide range of equipment designed and manufactured for dust control in industry is being exhibited by **Dallow Lambert,** of Leicester.

In this connection, equipment is available for foundry work, such as fettling, knockouts, and handling; for pattern shop and sawmill work; and for shipbuilding, welding, metal spraying, and polishing shops.

Unit dust-collectors are represented by the wet type (patent "Multiswirl") for explosive dusts) and the dry type "Dustmaster" and "Drytex." The "Multiswirl" M.S.E.10, booth model, with universal fitting, is illustrated.

The "Dustmaster" is a new type of unit dust collector, embodying new principles. This model is made in three main series, *viz.*:—The DM.50, the DM.100, and the DM.150. The elasticity of the range is so considerable that practically any type of dust or granular material, up to a capacity of 2000 cfm of air, can be handled.

Interesting items in the range of products exhibited by **Bryce Berger Ltd.,** of Ironbarks Works, Staines, are two examples of the new Bryce "B" size camshaft fuel injection pump, a 6-cylinder model with centrifugal governor, and a 4-cylinder model without governor, respectively.

By introducing this model, the range of Bryce fuel injection equipment available is extended and enables the Company to supply complete fuel injection equipment for a greatly increased range of applications. Special features of this pump include roller type bearings with ample load carrying capacity, an extremely rigid camshaft, location of the tappet designed to overcome wear in the pump housing, a simple phasing and calibration adjustment, and improved sealing against fuel leakage.

A full range of single cylinder flange mounted pumps and injectors, suitable for engines of 2½ to 2,000 hp is also exhibited, together with the H1-T nozzle produced for larger high-speed engines.

Other interesting exhibits include the Bryce hydraulic governor, which is suitable for marine propulsion and auxiliary generating sets and is the type used on Admiralty Standard Range 1 engines; a hydraulic governor of the type fitted to the Napier Deltic engine; examples of cooled injector systems to meet low-grade fuel requirements; and examples of Bryce fuel filters.

Berger exhibits include four applications of their "Handraulic" starters, fitted to various engines, and exhibits illustrating several new features now available on Berger starters. These are:

(a) A new piston type hydraulic accumulator for extremely cold operating conditions.
(b) An automatic mechanical charging pump for recharging the hydraulic accumulator immediately the engine has been started.
(c) A starter unit with front power take-off. This is particularly suitable for marine installations when an auxiliary drive is required from the front of the engine.
(d) A plunger-type pressure gauge which replaces the dial-type gauge previously fitted.

"The Lincolnweld" Full Automatic Welding Unit, exhibited by **Lincoln Electric Company Limited,** of Welwyn Garden City, consists of a welding head, control box and panel, flux hopper, reel and a coil of bare electrode, a quantity of cable, a set of all-purpose electrode drive rolls, and various contact assemblies and attachments. Direct current is normally supplied through two Lincoln SAE.600 motor generators in parallel, which provide adequate power for welding and auxiliary power for the operation of the "Lincolnweld" head.

In general, the unit operates as follows:—The bare electrode is inched and positioned directly above the point where the weld is to be produced before the electrode is brought into contact with the job. The appropriate flux then feeds from the hopper until it has formed a blanket deep enough to shield the arc. At this stage, an automatic control button is pressed, starting the welding cycle and producing the hidden arc between the electrode and the parent metal. The resultant arc heat fuses the electrode and the parent metal, and the weld is produced. Since the arc and molten metal are covered by flux throughout the operation, the weld metal is completely protected from contact with the air, assuring uniform welds of highest quality and making possible the use of extremely high amperage, resulting in faster welding at lower cost. Moreover, because the hidden arc is submerged by the layer of flux, spatter is entirely eliminated. During the welding operation, the unfused flux is normally reclaimed by means of a vacuum. Slag and particles of fused flux are easily removed and dispensed into a waste box.

The control of this unit embodies a d.c. control unit, including rheostat, for controlling arc voltage for the regulation of welding travel speed. The use of direct current for welding and control circuits assures a consistent supply of current in the entire system, despite variation in voltage of the shop power line. The main control wires operating the equipment are connected at the control box by means of multi-conductor polarity plugs. Various electrode sizes can be used without a change-over. For example, if required, the electrode drive roll will accommodate sizes of electrodes ranging from $^{3}/_{32}$ to $^{7}/_{32}$ in. A simple, adjustable knob controls the arc voltage for any size of electrode. One type and grade of flux and one analysis of electrode can be used with the same procedure for a wide range of steel analyses.

The self-propelled travel carriage type of fully automatic equipment can be adapted to suit a wide range of jobs and is used in general for applications where the work moves while the head remains station-

A setter with a brand new jig...

. . . merrily wagged his tail in time to the music and danced to the tune of 'Over the Lathes'.

"What," said the machine shop foreman, "is the reason for this jollification?" The setter, by now out of breath, replied, "I've just heard our machines are to be automatically lubricated by Tecalemit!"

A wistful look appeared in the foreman's eyes. "I wish sometimes," he said, "that I was a machine and could get well oiled at regular intervals!"

Tecalemit lubrication systems—fully automatic, semi-automatic or manually operated—feed every bearing with the correct amount of oil or grease at the correct intervals of time, regularly . . . unfailingly . . . efficiently. A Tecalemit engineer will gladly call to discuss your particular lubricating problems with you.

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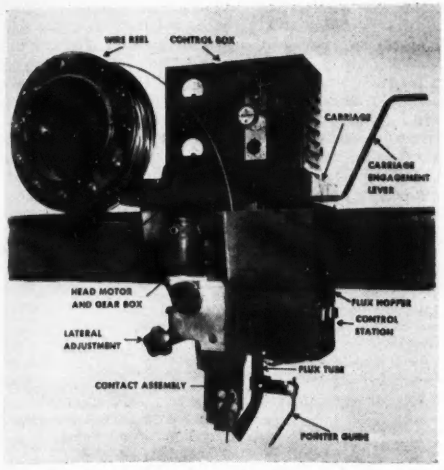
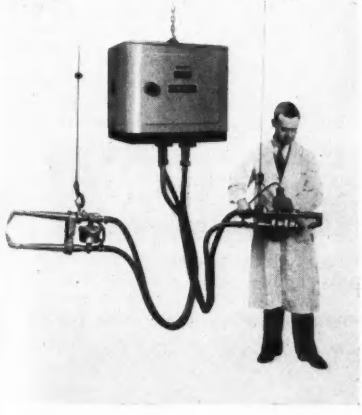


ary, whilst the carriage is motor driven along a beam. This equipment consists of a " Lincolnweld " head, a control unit, an electrode reel, a carriage and an assembly for butt welding. Attachments for fillet and lap welding are available with this equipment, together with two types of guide rolls, i.e., a double roll and a grooved roll. The double roll, which rides against both the vertical and horizontal members of the joint with sufficient clearance between to clear the tack welds, is used when fillet welding. The grooved roll is used for lap welding and rides on the corner of the upper plate.

The standard fillet welding attachment permits the " Lincolnweld " to be changed from butt to horizontal fillet welding within a few minutes, without changing the head or the electrode reel. This feature makes deep root penetration of fillet and lap welding easily obtainable in the horizontal position.

Amongst numerous examples of resistance welding plant, exhibited by **Sciaky Electric Welding Machines Limited,** of Slough, is their type SMC.100, motor driven stitch and pitch spot machine. Nominally rated at 100 kVA, this machine incorporates new features in automatic pressure control, and stitch speed control, with welding speeds up to 120 spots per minute and electrode pressure up to 1750 lbs. An air cylinder is fitted for electrode pressure compensation and also to give a retracting stroke. This unit is a general purpose spot and stitch welding machine, but its special features give it a great advantage in welding heat resistance steels, as used in the jet engine industry. A fully synchronous Ignitron panel, incorporating constant current control and phase shift heat control, is also incorporated.

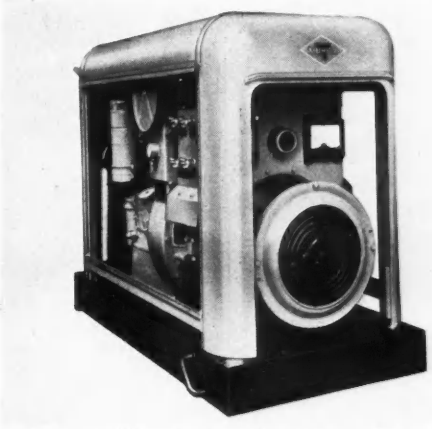


Another machine of new design is the type PSA.45 portable spot welding machine, illustrated. Rated at 45 kVA nominal, this machine incorporates a robust cabinet into which are assembled the welding transformer, compressed air control, weld current control, and timer control. Two welding heads of different types can be fitted, so as to cover a large variety of welding locations. A special feature in this machine is that the two heads are pneumatically and electrically interlocked, so that, if necessary, two operators can work together on the same structure. The interlocking arrangement ensures the correct functioning of the individual weld initiation.

Type S.A.C. 25/3, nominal rating 25 kVA, with a throat depth of 24 inches, is an air-operated spot and high-speed stitch welder of entirely new design. It is fully automatic and suitable for 18/8 stainless steel and Nimonic, and mild steel up to two equal thicknesses of $\frac{1}{8}$ in. Resistance capacitance timers for weld and stitch speed timing, together with Ignitron current control, are fully enclosed, but are very easily accessible. The change-over from single spot to automatic stitch welding is made simply by tumbler switch.

New electric arc welding equipment and new electrodes are a feature of the exhibits shown by **Murex Welding Processes Limited,** of Waltham Cross, Herts.

Among the new electrodes are the Murex " Speedex " electrode, specially developed for high speed manual welding, the Murex "Deepex" mild steel electrode of the deep penetration type, and the Murex " Coilex " electrode. This is a continuous extruded type of electrode of the mild steel type, designed for use in existing automatic welding machines.



The new Murex arc welding generator incorporates a new brush shaft principle, and a special feature of the equipment is its ability to vary the current in infinite steps, irrespective of the open circuit voltage. The generator is designed so that it can be incorporated in all Murex motor generator sets and also in Murex diesel and petrol engine driven equipment.

The generator, specially developed for arc welding, has drooping characteristics and a current range of 15/300 A for continuous hand welding and up to 450 A for intermittent work. The open circuit voltage can be varied between 70-90 V and a remote control can be fitted, if required. Also included is a polarity reversing switch, thus enabling the welding leads to be permanently connected to the two output terminals.

The new 250/300 A diesel engine driven arc welding equipment illustrated incorporates the Murex Type

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Other properties include:—

Wide range of resistance to chemical attack. High resistance to wear. A range of thermal conductivity. Not wetted by molten metal or slags. Non-seizing. Non-galling. Machinability. A range of electrical conductivity. Available in impervious forms. Low thermal expansion.

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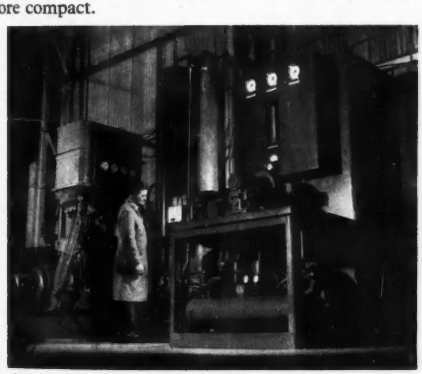
LWG052 patent drooping characteristic generator, which has a current range of 15/250 A for continuous hand welding, and up to 300 A for intermittent work. The generator is driven by an Armstrong-Siddeley air-cooled twin-cylinder engine, which is close-coupled to the generator. The unit is mounted on a bedplate and is complete with cover, silencer, fuel tank, etc. Three current ranges are provided on the generator and a shunt field regulator is included for fine adjustment. A voltmeter and ammeter are also incorporated.

A new 300/400 A diesel engine driven equipment incorporates the new Murex brush shift generator and a Perkins "P.4" engine. The two units are coupled together through a flexible coupling and are mounted on a bedplate. The unit is complete with all controls, canopy with sliding doors, silencer, fuel tank, and radiator.

Other Murex items include a series of single and double operator transformers, multi-operator transformer equipment, and the Murex low voltage device, which ensures that, in the event of any electrical defect, the equipment will remain at the safe position, thus warning the operator of the fault.

For the first time, a complete oxygen generating plant, suitable for installation in the user's own works, is being exhibited by **The Butterley Company Limited,** of London.

The oxygen produced is of high purity, is completely moisture free, and is suitable for all industrial purposes. It is also suitable for use as breathing oxygen in aircraft and hospitals. Special attention is drawn to the oxygen pump, which is an integral part of the plant, and eliminates the usual soap-and-water lubricated oxygen compressor, gasholder, and drier, thereby reducing maintenance and running costs, and making the plant more compact.



Any suitable, existing building can be used, and the generator is complete and ready to charge cylinders, or alternatively to feed works pipelines *via* a storage bank, if required. One of these oxygen generators, which are being manufactured in Great Britain under licence from Air Products, Inc., U.S.A., is illustrated.

The plant consists of three units in the smaller sizes and four in the larger sizes. The only installation work necessary is the running of a small amount of interconnecting piping, and connecting to the power supply. These generators can, however, also be supplied as completely mobile units, driven by diesel engines, and requiring no external connections whatsoever.

Among the many chemical products exhibited by **XZIT (G.B.) Limited,** of London, mention should be made of the following :—

"Serviron" is a permanently plastic, viscous coating, with unique lubricating qualities. It protects metal against oxidation and corrosion and can also be used to prevent deterioration and fungus growth on both wood and concrete.

S.R. Sludge Remover is a single-purpose fuel oil treatment, for petroleum-base oils and tar oils only, intended to clean oil tanks, fuel lines, and heaters, whilst at the same time improving combustion and the quality of heavy or residual fuel oils. On the other hand, S.S.R. Soot and Sludge Remover is a dual-purpose fuel treatment, combining the properties already mentioned with the ability to remove soot and scale from the fire side of the boiler right through and up the stack.

XZIT Universal Degreaser represents a new development in degreasing solvents. It quickly disperses oil and grease deposits, forming a stable emulsion with either fresh or salt water. It is a ready-mixed product, and does not require heating or stirring.

XZIT Diesel Fuel Oil Treatment is an additive designed to soften carbon deposits in diesel engines, thereby permitting their dissipation through the exhaust. This treatment tends to stabilise the oil and to assure a uniform condition and flow of oil at all times.

The need for a high-quality general purpose refractory material has long been recognised. "Brickseal Bond" is an air-setting powder, with a maximum recommended operating temperature of 3200° F. Mixed with water to form a slurry, it is applied by brush to the surface of bricks, when bonding or coating refractories.

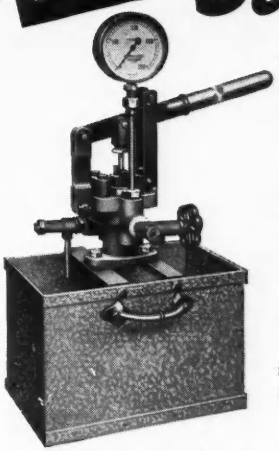
The glandless, self-priming, hydraulically operated tube diaphragm pumps, exhibited by **Merrill Pumps Limited,** of Sheffield, have been designed for handling acids, alkalis, chemicals, and abrasive slurries, and to make use of new engineering materials, particularly carbon and plastics, such as polyethylene, polytetrafluorethylene, polyvinyl chloride, etc. They also incorporate novel design features both in the diaphragm pumping unit and in the piston pumps, which have been designed for hydraulic operation of the diaphragm pumping units. A 12·5 gpm pump of this type is illustrated.

(*Continued overleaf*)

BA2

TEST PUMPS?

RING Bailey's



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Illustrated: Hand-operated concentric ram test pump, with 2 in. ram for rapid filling of vessel to be tested and ⅝ in. ram for obtaining the pressure. Suitable for pressures up to 1,500 p.s.i.

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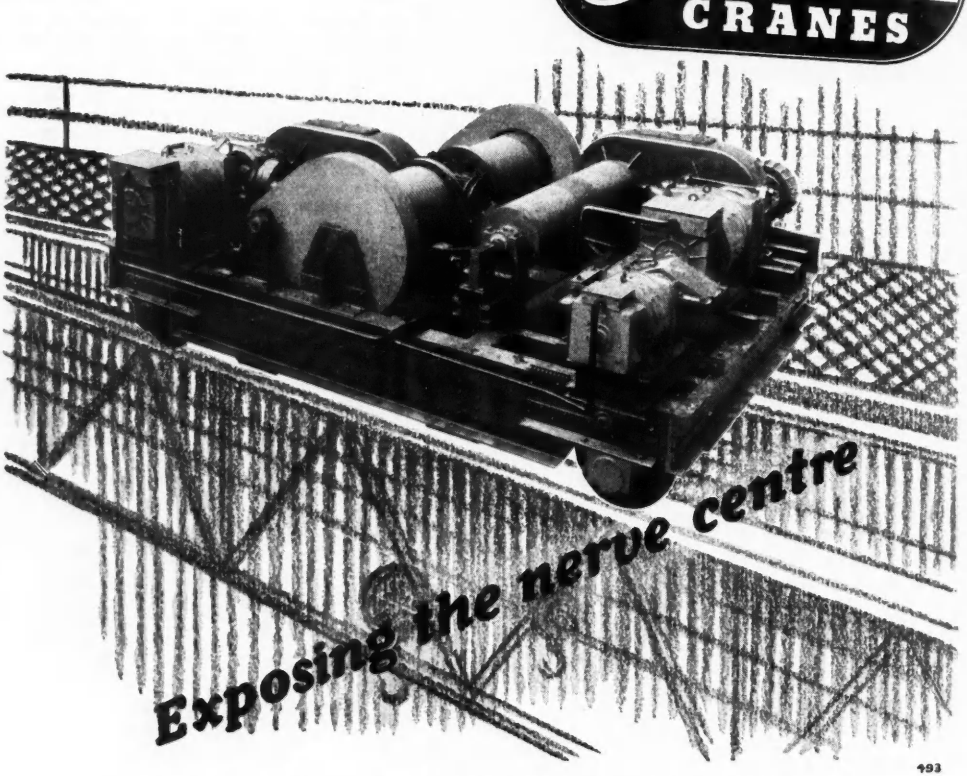

The modern overhead crane is an essential unit of industry today, and can be seen doing scores of different jobs in various works throughout the country. Not so well known is the crab, which is probably the most vital part of the crane, being directly responsible for the hoisting and cross travel motions. When necessary Stacreep Control can be fitted to standard crabs enabling slow speeds to be obtained on all motions, giving a far greater degree of control and finer setting.

The crab shown is of 60-ton capacity with an auxiliary hoist of 20 tons, and is designed for arduous duty in a steelworks.

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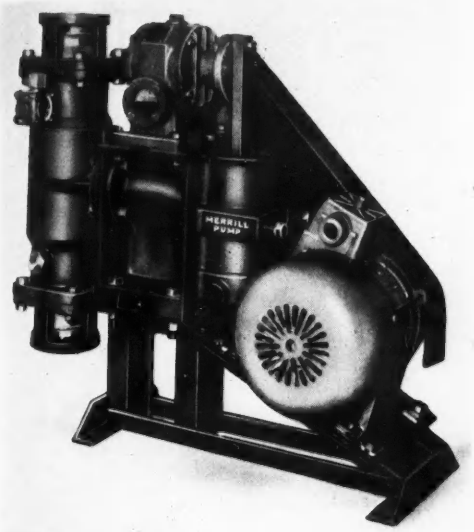


The special feature of these pumps is that mechanical parts are completely isolated from corrosive fluids handled by the tube diaphragm unit, which houses suction and delivery valve boxes of simple and economical construction.

The tube diaphragm unit is built into the pumping line and is, in effect, the pump. It is contained in a cast iron pulsation jacket unit which both protects it and provides an annular space around it. This annular space forms part of an enclosed hydraulic system, in which positive suction and pressure strokes are transmitted by the movement of a piston pump.

12·5 gpm and 25 gpm capacity pumps have been in production for some years. 100 gpm capacity pumps are now coming into regular production, and are an advance and improvement on the smaller pumps in several respects, *viz.*:—

(a) The suction and delivery valve boxes of the twin tube diaphragm units are of double conical shape, so that the flexible wall of the tube diaphragm itself can be used for sealing the tube diaphragm unit into the pumping line, without the use of stuffing boxes, packings, or gaskets of any kind.

(b) The movement of the tube diaphragm is limited by ribs and projection inside the cast iron pulsation jacket.

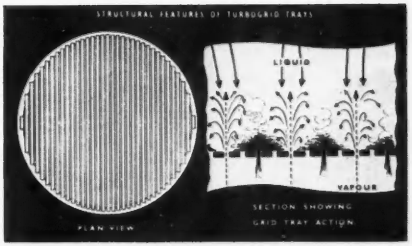
(c) A rubber lined junction box at each end of the pump unites the twin units, to give common suction and delivery connections.

(d) The liquid-sealed, double-acting piston pump is of extremely simple construction and novel design. It is operated by a self-locating lever carried on a crank disc, fixed to the output shaft of a worm reduction gear box. This lever slides and swivels in two submerged plastic bearings, one of which acts as a fulcrum point.

A working section of a distillation column, showing the new Shell Patent Turbogrid Tray in operation, is featured among the exhibits of **W. J. Fraser & Co. Ltd.,** of Dagenham, Essex.

In certain processes, particularly those in which liquid load is high, as in de-ethanisers, de-propanisers, stabilisers, and absorbers, or where column height is limited, this new, vapour-liquid contacting tray has striking advantages over the bubble-cap type. For a similar separation efficiency per foot of column height, turbogrid trays can have up to 100 per cent more capacity than a well designed bubble-cap tray, and as much as 80 per cent less pressure drop per tray.

For new installations, this extra capacity allows a saving of up to 50 per cent in the cost of column shells, with a corresponding saving in replacement costs. For existing plant, also, a large gain in capacity is now made possible by replacement of bubble-cap trays by turbogrid trays, which are easily serviced, and are of extremely simple and robust design.



In construction, the tray consists merely of a flat grating extending uniformly over the entire column cross-section, as shown in the illustration. The rectangular struts are of dimensions and number appropriate to the application and so designed that the flow of liquid is turbulent, with good vapour-liquid contact. Separation is equivalent to that in a bubble-cap tray, yet the simple shape and greatly reduced flow resistance give the tray much greater capacity and much less pressure drop.

W. J. Fraser & Co. Ltd. design and make the tray in England under licence from Shell, who hold the patents.

The efficient element in Pipeline Filtration

Y-PATTERN STRAINERS fitted stainless steel or monel screens. Available in gunmetal and cast iron from stock, cast steel, stainless steel, monel and aluminium to order.

For closer filtration to 2/3 microns porous metal screens are fitted. Readily cleaned by back flushing or washing in solvent.

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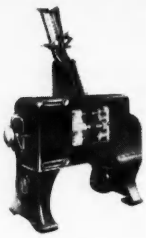
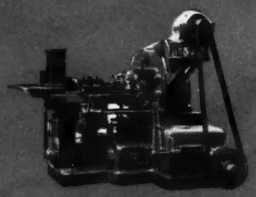
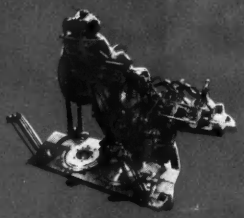


Flanger



Bodymaker

Side Seamer

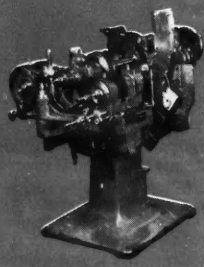


Strip Feed Press

Semi-Auto Seamer

Irregular Body Former

Air Tester



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B/14

NEWS OF THE MONTH

PERSONAL

Mr. H. Norman G. Allen has been re-elected Chairman of the British Internal Combustion Engine Research Association.

Sir Charles Colston, chairman and managing director of Hoover Ltd., has announced the following appointments:— **Mr. S. T. Matthews,** director, to be resident director, South America, **Mr. P. Attwood,** director, also to be a director, Hoover Industries Proprietary Limited, Australia, **Mr. C. H. Crowlie** to become general manager of Etablissements Hoover S.A., **Mr. V. C. Mumford** to become export manager, **Mr. H. E. Duggans,** to be resident manager in Hong Kong covering Far Eastern Division, **Mr. G. Cooper,** to be resident manager, Beirut covering Middle East Division, **Mr. J. Hallifax,** works manager, High Wycombe, to be production engineer, Hoover Industries Proprietary Limited, Australia, **Mr. P. C. Raphael,** purchasing manager, Cambuslang, to be administration manager, Hoover Industries Proprietary Ltd., **Mr. S. Roberts,** home sales manager and director, Hoover (Washing Machines) Ltd., to be deputy general sales manager, **Mr. R. T. Griffiths,** sales personnel manager to be field sales manager, **Mr. H. Wilcock,** field assistant, to be southern sales manager, **Mr. H. W. James,** Northern Branch manager, to be sales personnel manager, and **Mr. J. C. Shapley,** chief production engineer, Perivale, to be works manager, High Wycombe.

Mr. G. C. R. Eley, C.B.E., has been elected a director and deputy chairman of the Brush Electrical Engineering Co. Ltd., Loughborough. **Major N. E. Webster, O.B.E., M.C., M.I.Min.E.,** has also joined the Board.

Mr. John Harrison, former area production manager in the South Western Division of the National Coal Board, has been appointed managing director of Cyprus Copco, Nicosia, Cyprus, the latest company established by the Atlas Diesel Organisation.

Mr. R. M. Hilary, M.B.E., T.D., has joined D. Napier & Son Ltd. as commercial manager.

Mr. W. E. Johnson has been appointed head of the research division and a special director of Powers-Samas Accounting Machines Ltd.

Mr. William E. Miller, M.A.(Cantab.), Editor of "The Wireless & Electrical Trader," has been re-elected President of the British Institution of Radio Engineers.

Mr. Robert Onions, A.M.I.Mech.E., 44 Grenview Boulevard South, Toronto 18, has been appointed resident factory representative in Canada for W. H. Dorman & Co. Ltd., Stafford.

Mr. Edward Player, managing director of Birmid Industries Ltd., Birmingham, has been elected to the Board of the Midland Motor Cylinder Co. Ltd. **Mr. H. H. Hopkins** and **Mr. R. S. Waterhouse** have also been appointed directors.

Mr. John Reich has been appointed factory manager of the Hyster Company, Danville, Illinois. The Hyster Company has also factories at Portland, Oregon, and Niimegen, Holland.

Mr. R. F. Richardson, M.B.E., A.M.I.E.E., has been appointed assistant commercial manager of the British Electricity Authority.

Mr. W. G. A. Russell has been elected a director and chairman of Glynwed Tubes Ltd., Bilston, Staffordshire, in succession to **Mr. F. Wallis,** founder of the Company, who retired, but is remaining on the Board. **Mr. N. Forbes** has been elected secretary, in succession to the retiring **Mr. W. H. B. Hatton.**

Mr. K. G. Sharp has been appointed blast-furnace superintendent at the Margam Works of the Steel Company of Wales Ltd.

The Institution of Metallurgists announce that H.R.H. The Duke of Edinburgh has graciously consented to open their Platinum Metals Exhibition at Grosvenor House, London, on Monday the 19th October. The exhibition is being held to mark the Triple Jubilee of the British Scientist, William Hyde Wollaston's announcement of his discovery of the precious metal palladium.

The exhibition which will be open to the public from 22nd to 24th October, will show the vital part played by the platinum metals in science and industry today.

BUSINESS NOTES

Cockburns Ltd., Clydesdale Engineering Works, Cardonald, Glasgow S.W.2, and North Shields, have opened a London office at 175 Piccadilly, W.1, under the management of Captain (E) G. R. Cook, O.B.E., D.S.C., R.N.(ret.).

William Jessop & Sons Ltd. and **J. J. Saville & Co. Ltd.,** Sheffield, have opened a new office at York House, 12 York Street, Manchester 2, under the management of Mr. H. Carr.

F. J. Edwards Ltd., 359/61 Euston Road, London, N.W.1, have formed a new company, F. J. Edwards (Canada) Ltd., 16 Watsons Drive, Etobicoke, Toronto 18, Ontario. Mr. H. A. Johnson is President, Mr. G. M. Hayward, vice-president, and Mr. J. L. Hall, resident managing director of the Canadian company.

The works of **Armstrong Whitworth & Co. (Pneumatic Tools) Ltd.,** Gateshead, have moved to larger premises on the West Chirton Trading Estate, North Shields.

Geo. W. King Ltd. have now completed the removal of the whole of their works and offices to Stevenage, Hertfordshire.

The English Electric Co. Ltd. has received a contract from the Bonneville Power Administration, Oregon, U.S.A., for a 250,000 kVA 3-phase transformer bank for service in the Administration's 230,000-volt system. The value of the contract is $650,000, and the equipment will be manufactured at the Stafford Works of The English Electric Company.

Restrictions on the Use of Molybdenum in case-hardening and constructional steels in Member countries of the Organisation for European Economic Co-operation have been suspended by a decision of the Council of the Organisation.

These restrictions were imposed in May 1952, as a result of shortages of molybdenum and nickel on world markets. The new decision does not apply to nickel, for the present improvement in the supply situation is not sufficient to justify the abolition of the restrictions in force.

The Council has instructed the Iron and Steel Committee to follow closely the supply position for molybdenum, and to make appropriate proposals for the final repeal of restrictions or for their re-imposition, should the supply position make it necessary.

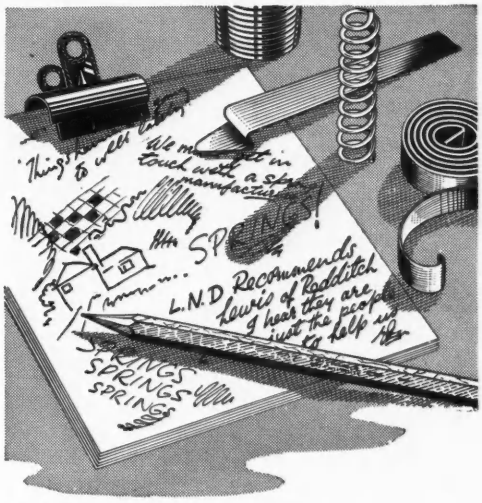
A New Stud Welding Organisation has been formed recently to operate as a separate entity within the Crompton Parkinson group of companies. Its purpose is to co-ordinate the sales and engineering facilities for both the Nelson and Cyc-Arc ranges of equipment with the object of providing a comprehensive service for present and future users of stud welding equipment.

Mr. F. Foster, M.Sc., A.M.I.E.E., is general manager of the Stud Welding Organisation, with Mr. R. W. Taylor, A.M.I.E.E., M.Inst.W., as sales manager (Home).

Crompton Parkinson Limited will market traction, commercial and car starter batteries under the brand name "Crompton," thus superseding the name "Young" which has been used for over 25 years since the Young Accumulator Co. Ltd. began manufacturing in 1927.

Simultaneously with the change of name, the new "Crompton" car starter battery is being introduced. Since battery performance and life largely depend upon plate design and reliability, that is, the quality of the active material and the ability of the grid to resist corrosion and distortion, research in the past few years has been undertaken to produce a battery plate which gives greater power and has a longer life.

A new design of grid made from "Nilcrode" alloy retains active material more securely, stays rigid and resists corrosion. A new



L.N.D. certainly knows what he is talking about. Lewis of Redditch design springs to do just the job you want, and they turn them out from top-quality materials so that they will last as long as your product. It might be worth while to have a word with us, don't you think?

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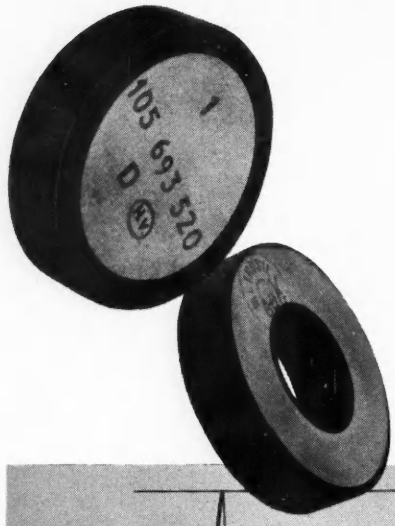
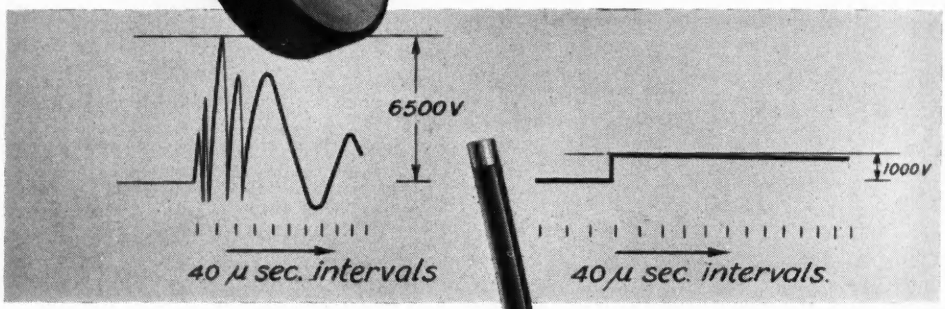
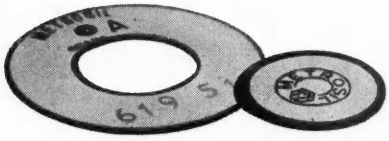
METROSIL

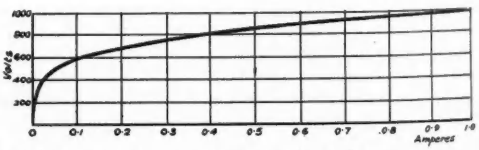
means protection against surge voltages





The non-linear volt-ampere characteristic of Metrosil resistors is exploited to provide a convenient means of safeguarding all types of electrical equipment against surge voltages. Based on silicon carbide, Metrosil is usually made in the form of discs, but rods can also be produced if required. These standard products are stable and convenient in size, standard discs ranging from $\frac{3}{8}$" to 6" in diameter. Typical applications for Metrosil products include the protection of field coils, relay coils and solenoids, instrument relays, condensers, tap-changing switches and power transmission lines. Other applications include spark quenching, protection of instruments under fault conditions, relay sensitivity improvement, etc. Please write for full technical details.





Relation between current and voltage for a typical "Metrosil" disc, examples of which are illustrated at the top of this page.

METROPOLITAN-VICKERS ELECTRICAL COMPANY LIMITED · TRAFFORD PARK · MANCHESTER 17

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formulation of active material gives increased power, especially for cold starting.

In order to realise the longer life obtainable from the new plate, Crompton car batteries now incorporate " Dri-Stor " microporous separators which are virtually indestructible and completely unaffected by immersion in acid.

Every container is made of moulded hard rubber capable of withstanding rough handling and continual vibration without cracking and resultant leakage.

Other features include larger connector bars with increased sectional area to give higher starting voltage ; and the non-splash vent plugs with finger grips designed for easy, speedy unscrewing. The battery has an unlimited shelf life and can be stored unfilled for an indefinite period without deterioration.

FUEL CONSERVATION

A Productivity Report on Fuel Conservation has just been published by the British Productivity Council. Since its compilation the decision has been taken to set up in the U.K. a Fuel Efficiency Organisation, for the initiation of which the British Productivity Council has accepted responsibility. The Report presents the findings of twelve fuel utilisation specialists drawn from the engineering, heating and ventilating, brewing, chemical, textile and paper industries, who last year made a specific study of power installations and manufacturing and process plants in the United States to ascertain how fuel-saving methods used in that country could be applied profitably to industry in Great Britain.

The indictment of waste in this country is drawn in sweeping terms :

" It is a sad commentary upon our National intelligence that from all the hard-won coal we consume some 80 per cent of the heat is lost, a great deal of it because of ineffective utilisation."

" It has been estimated that the fuel consumption of manufacturing industry in the U.K. might well be reduced by something of the order of 30 per cent . . . " The Team quotes figures showing that about ten tons of excess air pass through many inefficiently operated Lancashire boilers *every hour* . . . " All this heat, which is uselessly discharged up the stack, represents an unforgivable waste of fuel on a grand scale . . . There are 120,000 Lancashire boilers in the U.K. Its repression . . . might reduce the consumption of industrial steam-raising fuel by as much as 10,000,000 *tons of coal per annum*."

" At least 25 per cent of the heat escapes through the roof and ceiling construction of an uninsulated house " ; simple insulation could reduce this loss by 70 per cent.

" The production of (electrical) energy in a condensing cycle . . . involves on the average the wastage of over 70 per cent of the heat available in the fuel."

(In brewing) " too often the firing of boilers is left in the hands of unskilled men who may easily waste 500 tons of coal a year on a relatively small plant—more than the annual production of a miner."

" . . . if the average mangling performance throughout the British cotton finishing industry were improved to the extent of a general reduction of five per cent in the weight of water retained, a saving of coal of the order of 10,000 tons a year would be achieved."

The paper-making process requires such large quantities of warm water that a good use can always be found for any waste heat it is possible to recover, and " in the U.K. the paper industry is not taking advantage of the opportunities offered."

" In Great Britain (railway) locomotives alone consume about 13·5 million tons of high-volatile, large-sized coal per annum . . . at an average efficiency probably not greater than six per cent."

" It is estimated that in Great Britain the entire output of 10,000 miners is wasted every year in the form of unnecessary smoke . . . the Smoke Abatement Society of Great Britain estimates that the nation pays at least £100,000,000 a year on account of smoke."

" It is within our capacity as a nation to save, on the present level of industrial activity, no less than 30 million tons of coal per annum without impairing any services." This figure is a conservative one and it is felt that savings considerably in excess of this amount would be possible if capital could be made available to replace all obsolete fuel-using equipment. This forecast is based on the results which emerge from the work of the second Fuel Efficiency Committee set up by the British Government in 1941.

The Team emphatically commends to the attention of British industry at large two significant lines of attack adopted in the American drive for fuel economy. The starting point of one was consideration of the relative costs of mechanical power and man-power : " The American industrialist takes full advantage of mechanised power and is prepared to give his workers the maximum use of it because he realises that it is infinitely cheaper than human effort. He has accepted and put into practice the principle that it is much more important to keep the machine, not the man, working hard. This is claimed to account largely for the high rate of productivity in American industry." The other was the inception of the dual-purpose generating station : " One possible method of improving efficiency in the public generation of electricity is by the adoption of dual-purpose stations, producing and selling both heat and power. Such stations would be equipped with back-pressure or pass-out turbo-generators supplying exhaust or bled steam to nearby industrial, commercial or domestic premises.

" Efficiency in the use of fuel should not be regarded as meaning only thermal efficiency. It comprises the overall effect of methods of fuel utilisation upon the process as a whole, including labour costs, quality of product, rate of production and so forth. Within this broad definition there is wide scope for economy through the adoption of good practice. It governs productivity.

" By and large, British industry has not replaced or materially modified its fuel and power equipment since the first world war; it is old and inefficient. But machinery that was perhaps good enough when coal was in abundant supply and cost as little as ten shillings per ton at the pithead is not good enough today and remains an obstinate barrier to the achievement of real fuel economy.

" Somehow this barrier must be removed ; an incentive must be provided to break the deadlock. This is the heart of the problem and it turns on the financial predicament of industry at large. It is unlikely that industry will maintain and improve its standard of fuel utilisation unless it is actively assisted, persuaded, or even coerced to do so by legislative means. Given inducement, the many plans and projects that have been developed but perforce postponed will be brought out of their pigeon-holes."

" By taking control of the production of coal, gas and electricity the State has accepted responsibility for the fuel services. It cannot therefore stand aside and permit waste or improper use of these fuels to continue . . . the fuel technologist has always felt nationalisation of the basic fuel industries to present great possibilities of substantial benefit, *provided real co-ordination could be achieved between them.* In the long term, concern would be with such matters as :

Integration of gas and electricity production on the same site

Generation of power from gasworks waste heat and/or from an orthodox power plant using coke breeze, both supplying power to the grid

Supply of pass-out steam and power from a generating station to a gasworks."

In the short term, many vexed questions await solution, among them :

Is it in the national interest that electricity, a costly and refined product, should be used for space heating, except where gas is not available ?

Is it not essential, in view of industry's future needs for power, that the functions of electricity be confined to the provision of power, light and certain specialised heat processes ?

Is not gas the right fuel to retain on tap for space-heating purposes (occasional heating) ?

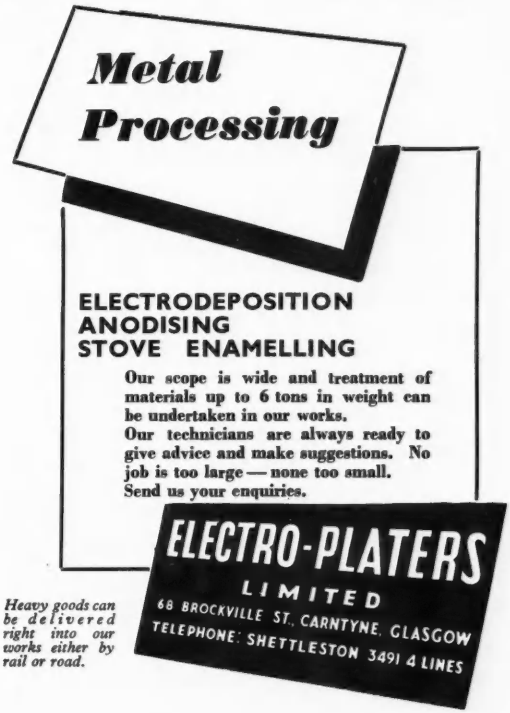
Seeing that the base load of space heating can only be carried by solid fuel, is it not in the country's best interests that smokeless fuels be used, particularly in the domestic sphere ?

Can we produce more smokeless fuels, improve their distribution and reduce their cost ?

Where electricity is available, should gas lighting be used for public services ? "

No evidence can be found, says the Team, of any attempt made to co-ordinate on either the long- or the short-term policies indicated. On the contrary, it states : " we see each industry—coal, gas and electricity—consolidating its own policy and pursuing its own line of action, presumably because the wider national interest is none of its responsibility."

" With the country looking for an authoritative line of action, we suggest one bold stroke to set us on the right road : enact legislation to create a permanent and non-political Fuel and Power Board.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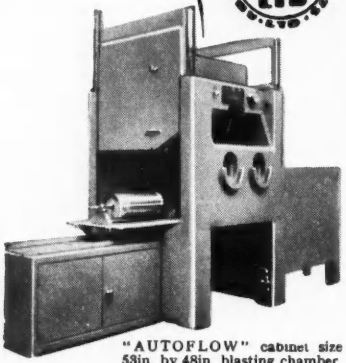
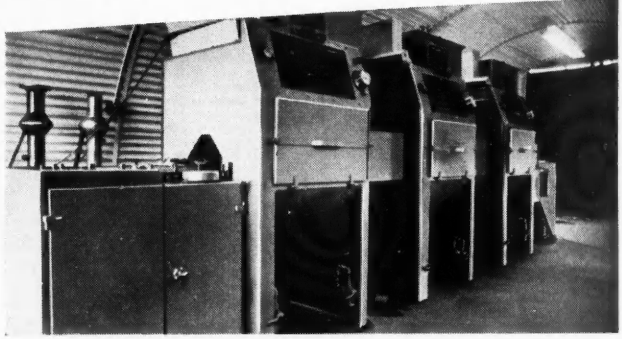
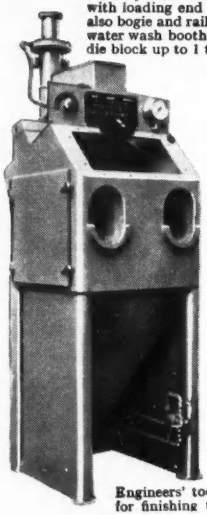
VAPOUR BLASTING EQUIPMENT



"AUTOFLOW" cabinet size 53in. by 48in. blasting chamber, with loading end and cupboard, also bogie and rails - Cabinet and water wash booth for processing die block up to 1 ton.





Engineers' tool-room model, for finishing tools and dies

Continuous Feed 'Autoflow' Unit

For processing turbine blades, output 1,000 per hour.

Since 1942 we have been manufacturing vapour blasting equipment; these ten years of research and manufacturing experience have given us the "KNOW HOW" that few, if any, can approach in our field. The basic design of our new "AUTOFLOW" equipment has been proved by thousands of hours of service. Our "AUTOFLOW" units have been designed to meet the specific needs of the Royal Air Force, Ministry of Supply, and leading aircraft manufacturers. To keep abreast of the advanced requirements of aviation and industry, profit from our years of experience—write for an illustrated booklet.

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PIONEERS IN THE DEVELOPMENT OF VAPOUR BLASTING EQUIPMENT

Let that board formulate whatever policy is necessary, but above all let it get on *first* with co-ordination."

"Steam is perhaps the commodity most universally consumed in British industry and perhaps the worst used, primarily because our traditional practice has been to divorce processing departments from engineering departments . . . Too often the works engineer who knows, or ought to know, the cost of these services has no jurisdiction whatever in the department or processes in which steam is consumed. His protests at its wasteful usage seldom fall on sympathetic ears, notwithstanding that for every one per cent that might be saved in its production, three per cent or more might be saved in its utilisation. It is this kind of traditional practice in industry which it is necessary to change, and change can come only from a better appreciation of the problem by executives."

Measures that can be taken to avoid the very heavy waste of steam in industry are well established and certain of them are dealt with in the Report.

The accurate control of steam pressure is a fundamental necessity in most industrial plants although this is not always realised, and where the process pressure is low control must obviously be very close since less margin is available to cover downward variations of pressure. There are several possibilities : (a) automatic combustion control at the boiler, (b) pressure regulation in the steam mains, and (c) thermal storage of one kind or another.

"Much of the harm done in an industrial plant by allowing heavy steam peaks to develop could be avoided if work were properly scheduled and large consumers brought into operation in sequence instead of simultaneously, particularly at the beginning of each shift . . . A greater degree of control and a better understanding of all the implications would most definitely improve productivity in every sense of the term."

". . . Where it is practicable, all condensate should be collected and returned to the boiler, or else usefully employed, conserving both the water and its heat content."

In this country, in spite of numerous attempts by a few trade organisations, very little has been done to make general use of "degree-days" for checking and forecasting fuel consumption and the requirements of space-heating plants, as a means of saving fuel. Much has been accomplished, however, in this direction in colder parts of the U.S. and the Team was made aware of the importance attached to it by engineers in charge of space-heating plants.

"Most industrial processes that use heat reject a proportion of it in the form of gases, vapours, hot effluents, or cooling water, a great deal of which can be economically recovered." Although the recovery of waste heat is understood in British industry, there is still scope for fuel economy in this direction, and suggestions for effecting it are outlined.

Almost all manufactured products are dried at some stage in production . . . it is gratifying to learn of the widespread investigations that are being made in Britain into this process and its related problems ; it is urged that the movement should be speeded up.

The Team advocates a wider and more general use of high-pressure hot water systems as opposed to steam for heat distribution, particularly in new factories.

In the conservation of fuel there is probably no single factor that has such common application in industry and is more important than insulation. The function of thermal insulation has been understood for a very long time . . . and it is all the more remarkable, therefore, that the financial benefits which would accrue to industry by the elimination of preventable heat loss by means of effective insulation have not received greater recognition. The subject is of such wide importance that the Team outlines the great possibilities for fuel saving that it presents in steam engineering, in high-temperature installations and in buildings.

Economic value of research

The Team feels that "in the U.K. much more emphasis should be placed on applied research and the extension of laboratory work on pilot-scale and full-scale development . . . The importance of research and development in the U.S. in the field of industrial steam, heat and power was manifest to the Team, the users of steam raising and power generating equipment, the manufacturers and the different fuel interests all taking part and all actively co-operating. In the U.K. we could copy with advantage the drive and scope of this effort."

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* Copies of the Report can be obtained from the British Productivity Council (formerly Anglo-American Council on Productivity : U.K. Section), 21, Tothill Street, London, S.W.1, price 5s. post free (excluding air mail).

GREAT BRITAIN'S AIRCRAFT INDUSTRY SHOWS ITS WARES

The 1953 Display of the Society of British Aircraft Constructors has a three-fold theme. It shows the pattern of Great Britain is modern Air Force. It demonstrates the growing expansion of the export trade in turbine-powered airliners. It gives a hint of what British designers plan for the future.

Every kind of aircraft in this most modern of armouries—jet bombers, jet fighters, transports and trainers—have been demonstrated in flight.

There are the three "V" bombers (the *Vulcan*, *Valiant* and *Victor*), each capable of carrying a big atomic load to distant targets at near-sonic speed. Backing them up are the famous *Canberras*.

Then there is the fighter defence force, being equipped with the *Swift* and *Hunter*. These two supersonic machines, now to be demonstrated with powerful afterburners, are taken from the head of a production line from which hundreds will follow for the squadrons.

The *Javelin* delta fighter is there, the last word in all-weather and night-fighting equipment, showing the delta planform producing the maximum of performance from a two-seat radar-carrying weapon.

Transport Command's growing strength has been demonstrated in the form of the large *Beverley* freighter which carries military loads and troops up to a total weight of 20 tons. A glimpse of transports to come is also apparent in the *Valiant* jet bomber, a transport version of which is under development for air trooping.

To complete the picture there is the training service, well represented by light aircraft, jets and the bigger crew trainers. For the future there are such types as the *Avro* 707*C* delta trainer and the jet *Provost* (in model form at Farnborough) on which jet age pilots will learn their trade.

This year, and this year's SBAC Display, also shows the growing pattern of Great Britain's naval air strength.

First there is the concentration on aerial submarine hunters and killers. The *Gannet* has now been joined by the Short *Seamew*, a "utility" sub-hunter ordered straight off the drawing board for the Navy. These two types have the added virtue of standardization, both being powered by basically the same type of turboprop engine, the *Mamba*, which can fly on ship's diesel, kerosine or petrol, or a mixture of all three.

Then there are the fighters—the *DH* 110 for all-weather radar work, now being developed for naval carriers, and coming along to join it the new swept-wing twin-jet fighter from the Supermarine Company, the prototype of which is due to fly soon.

On the commercial side, Great Britain's trio of turbine transports (with a total of £21½m in orders on the books) has been flying at Farnborough. There is the turboprop *Viscount*, already well established on BEA's air routes and about to go into service with Air France. There is the turboprop *Britannia* with its new *Proteus* 3 engines ; and the production *Comet* 2, the second stage in jet-liner development, for the longer international air routes.

Backing up these front-line transports will be the feeder-liners, executive transports, aerial "tramp steamers"—the aircraft which fill one hundred and one everyday unspectacular roles throughout the world.

The Industry will also draw aside a small corner of the veil which hides the weapons of the future—the guided missiles and their new engines.

Inside the great Exhibition Hall more than 200 companies have displayed what amounts to the anatomy of the modern aircraft—new engines, new methods of construction, materials and equipment, and models of new aircraft.

The following paragraphs describe some of the things shown.

Jet pilots of the future will be able to see their position at a glance on a new radar-controlled map now being developed for small fighter

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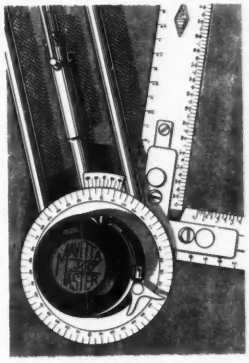

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planes. The map is a lightweight version of the Decca Flight Log.

This fighter-size Flight Log weighs only one quarter of the larger version now being built for larger airliners. Its total weight is about 15 lb. It will also go into other small aircraft such as helicopters.

Hundreds of thousands of pilots have been trained on the single-seat indoor ground flight trainer—the miniature fuselage which realistically turns and spins and is used for instruction under instrument flight conditions—that is, flying at night or in bad weather.

Now the British firm Air Trainers has built a twin-engined ground trainer to give the same kind of instruction to airline pilots. It has the realistic performance of a modern twin-engined airliner and "cruises" at 280 mph at 6,000 ft and will seat a crew of two pilots.

It is fitted with a full complement of radio equipment, covering the many different types used by airlines across the world, and has a complete instrument panel and controls.

A jet seaplane on skis was shown in model form at Farnborough by Saunders-Roe—who have pioneered the fighter flying-boat in Britain.

The skis of this fighter project will retract into the bottom of the fuselage on take-off, so retaining the streamlined form. Saunders-Roe have achieved a design which actually weighs considerably less than would a retractable land undercarriage.

Tests made with model flying-boat fighters in tanks show that skis (or hydroskis as they are sometimes called) reduce take-off runs and make it possible to take off in very heavy seas. Ski fighters would also be able to take-off from ice and levelled snow airfields, as well as water.

Gas-turbine powered helicopters were shown in model form. In particular there was important new work by Percivals, one of the latest British companies to begin helicopter design.

A new system of fuselage construction has been developed by a British designer. Known as the "tensioned-skin" process, it is suitable for all types of fuselage which have double-curvature (i.e. which curve in both planes). Instead of using expensive stretcher presses to induce double curvature in the fuselage skin, the skin sheets, which run almost the whole length of the aircraft, are cut to their final shape in the flat. Double curvature is cleverly induced during actual assembly.

The formers and stringers are riveted to the skin sheets (all of which are identical in shape) and then joined together along a jig built to the final shape of the fuselage.

After the cigar-shaped fuselage has been completed, the windows, doors and the apertures for wing attachments are cut out of the metal skin.

On display on constructors' stands at Farnborough have been examples of the most recent progress made with developing aircraft structures machined from the solid with outer skin, stringers and formers in one piece, instead of riveted or resin-bonded together as is usual in most aircraft flying today.

Although involving particularly careful design and intricate machine-work, these integral panels are believed by designers to be the answer to the quest for more efficient structures in both small high-performance aircraft and in the large highly-complicated modern transport.

Complete tailplanes and wing sections will be shown.

British manufacturers have been considering the possibility of using a new foam of structure on future high-performance machines which consists of filling the shell of the fuselage with a strong foam plastic compound.

A special plastic, known as Sebalkyd, has been developed by I.C.I., and used on the construction of a high-speed Towed Target built by Air Service Training.

Classified Advertisements.

The rate for all classified advertisements is 6d. per word; in bold print 9d. per word; minimum order 6s. Box number advertisements 1s. extra. Instructions together with remittance must be received not later than the 3rd of each month for advertisements to appear in the same month's issue.

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WANTED.—Copies of the March, 1953 issue of "The Engineers' Digest" urgently required. Also Jan., 1949, June, 1950, and Dec., 1951, issues at 3/6 per copy.—Subscription Dept., 120, Wigmore Street, London, W.1.

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1. Cast Iron Gutters. Details of a new process of making cast iron gutters are given in an extremely well presented 8-page booklet. Each step of the process is described and illustrated in colour, and comparisons are made with traditional methods.

2. Portable Spot-Welder. Details of a portable spot-welder are given in a leaflet. An adjustable carrying stirrup is available with this machine, enabling the operator to use the welder at any angle with a minimum of fatigue and with maximum ease of movement.

Water-cooled tongs come directly from the transformer, thereby giving high production capacity at low kVA input; where no water supply is available, uncooled tongs can be used for lower production capacity.

The welder has a capacity ranging from 300 spot welds per hour with 14 × 4 S.W.G. to 2000 per hour with 22 × 22 S.W.G.

3. Oxygen Generators. Descriptions and specifications of a range of high purity oxygen generators are contained in an attractively presented 24-page brochure. In addition to a number of interesting diagrams and illustrations, details of ancillary equipment, such as air separation units, air compressors, air purifiers, etc. are given.

4. Controls and Counters. In a series of three illustrated pamphlets, details are given of a.c. solenoid controls, batching counters, and electronic counters respectively.

The solenoids are intended for the electrical control of all types of engineering machinery, and develop a pull of either 10 or 15 lb at a stroke of 1¼ in.

The batching counter is designed to count products at up to 1500 per minute, to give a visual indication of the total at any instant and to divide automatically the output into batches of any desired quantity.

The electronic counter is a general-purpose unit for counting products which are partially or entirely metallic and either ferrous or non-ferrous. Fitted to presses, automatic machinery, conveyors, etc., its 6-figure counter provides an accurate and direct indication of output.

5. Electrostatic Precipitation. A very well produced and illustrated 64-page publication gives a comprehensive survey of the principles and practice of electrostatic precipitation. Included is valuable information on the design and applications of precipitators, with special reference to their use in power stations, chemical and metallurgical works, etc.

6. Reducing Valves and Water Heater Controls. A 4-page brochure describes a steam and air reducing valve, which is a revolutionary departure from the recognised type of diaphragm reducing valve. In this new valve, a pilot-operated element is subject only to the difference between itself and atmospheric pressure. It works to dead shut-off, is not affected by fluctuating pressure, and can be stripped while in position.

A supplementary 4-page brochure gives details of a water heater control, which is virtually noiseless and suitable for all applications where there is no objection to mixing steam with water at pressures up to 80 psi. Such applications include hot water for hand-basins, ablution fountains, and swilling tanks.

7. Rewirable Cartridge Fuses. A series of leaflets, neatly presented and bound in a folder, describes a wide range of cartridge fuses, fuse links and units, etc. Also included are comprehensive details of test results, with oscillograms, on these fuses.

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